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STUDY OF THE TECHNOLOGY AND COSTS ASSOCIATED WITH DREDGING AND OVERBURDEN CLEARING OPERATIONS FOR THE RECOVERY OF PEAT

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BY:
KESMARK LTD.
TORONTO, ONTARIO
G. B. MORRIS

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II. BREF RESUME DES RESULTATS DE L'ETUDE

Depuis de nombreuse années, le dragage par coupage et aspiration a été considéré comme un moyen économique d'excaver et de transporter de grandes quantités de limon, d'argile, de sable, de gravier et de pierres. Ces dragues consistent en une grande coque flottante supportant un couteau rotatif qui, abaissé dans l'eau, excave un banc de sol à 10 - 20 mètres de profondeur. Le couteau rotatif produit une boue de sol et d'eau contenant entre 10 et 30% de matières solides en poids, qui est aspirée dans une pompe montée à bord qui refoule la boue dans des canalisations pour la transporter à des distances pouvant atteindre 30 kilomètres.

Dans l'est du Canada, d'importants volumes de tourbe ont été déplacés par des dragues à couteau et aspiration mais cette tourbe est normalement mélangée avec de la terre. Le dragage par coupage et aspiration de la tourbe seule constitue un travail tout à fait différent.

La structure de la tourbe est différente de celle des sols minéraux et sa densité est inférieure à la moitié de celle de ces derniers. La structure cellulaire de la tourbe est telle qu'elle contient d'importantes quantités d'eau qui ne peuvent être libérées que par l'application de chaleur. Des procédés physiques comme le broyage, la compression ou la centrifugation diminuent sa teneur en eau mais dans une petite proportion seulement. En bref, lorsqu'on pompe de la tourbe, on pompe entre 10 et 20 fois plus d'eau pour un poids donné de tourbe alors que, pour l'argile par exemple, cette proportion serait comprise entre 3 et 6 fois plus d'argile pour un poids d'eau. De plus, la capacité de pompage de la boue est limitée à une concentration maximale de 10% de tourbe, en poids.

Les dépôts de tourbe sont relativement peu profonds et, pour pouvoir être dragués, ils doivent être à une profondeur supérieure à 2 mètres; ceux-ci ne dépassent probablement pas les 6 mètres. Des approvisionnements adéquats en eau doivent être disponibles près du dépôt de tourbe pour remplacer les importants volumes de tourbe et d'eau pompés du dépôt jusqu'à une usine de traitement productrice d'énergie.

Sur place, la composition de la tourbe combustible varie, celle-ci contenant entre 85 et 97% d'eau; c'est pourquoi les dépôts choisis pour être dragués doivent avoir une teneur en eau de 90% ou moins parce qu'il faudrait pomper en volume le double dans le cas d'une tourbe contenant 95% d'eau pour obtenir le même résultat. On considère que la tourbe déchiquetée par le couteau de la drague peut être pompée si elle contient 10% de matières en poids mais une certaine dissolution par l'action du couteau est inévitable. On considère qu'une boue contenant entre 7 et 8% de matières peut être transportée jusqu'à une usine de traitement. Le niveau de l'eau dans l'étang de dragage doit être maintenu à une profondeur adéquate pour que la drague flotte et cette condition exige probablement que l'étang soit endigué et que le niveau de l'eau de l'étang soit contrôlé par addition d'eau provenant de cours d'eau ou de lacs voisins.

L'équipement de dragage de la tourbe doit être différent de l'équipement de dragage utilisé normalement. La coque de la drague doit avoir un faible tirant d'eau pour réduire au minimum la hauteur des digues de l'étang à construire. Parce que les dépôts de tourbe sont peu profonds, la drague doit pouvoir effectuer de rapides mouvements horizontaux. De plus, le couteau doit toujours attaquer et couper le front de taille de la tourbe sans interruption à mesure que la drague avance ou que le couteau oscille d'un côté à l'autre. Enfin, la position du couteau doit pouvoir être contrôlée verticalement dans d'étroites limites pour pouvoir couper continuellement tout le front de taille de la tourbe et, en même temps, éviter de couper dans le fond minéral de l'étang, ce qui contaminerait la boue de tourbe. Le couteau doit être capable de laisser un fond lisse sans crêtes et de déchiqueter les racines et les arbres qui poussent dans la tourbe ou qui s'y sont déposés pendant sa formation. Des étangs ou des réservoirs de compensation sont probablement requis pour alimenter continuellement l'usine de traitement lorsque la drague ne fonctionne pas, par exemple lorsque la canalisation de dragage est déplacée ou que des réparations sont effectuées.

Trois emplacements ontariens ont été sélectionnés pour évaluer l'ordre de grandeur des coûts théoriques d'une tourbe draguée acheminée jusqu'à une usine de traitement (voir Figure 1). Toutefois, pour les grands dépôts de tourbe, on ne dispose pas de l'information détaillée nécessaire pour faire une étude de faisabilité du dragage d'un emplacement spécifique; les recherches nécessaires restent à faire. Il existe toutefois de nombreuses grande zones de tourbe en Ontario, suffisamment étendues et profondes pour convenir au dragage.

Les estimations des coûts de dragage de la tourbe, basées sur les conditions décrites dans ce rapport indiquent que, pour une durée de la drague de 20 ans, les coûts du dragage en dollars de 1981 seraient de l'ordre de $3.00 à $5.00 par tonne de tourbe sèche acheminée jusqu'à une usine de traitement à l'état de boue aqueuse contenant entre 7 et 8% de tourbe en poids. Les coûts de la tourbe contenant 50% d'humidité, utilisée pour la production de vapeur en Europe, si elle était acheminée sous forme d'une boue semblable, seraient inférieurs de moitié.

Il est peu vraisemblable que le dragage de la tourbe puisse être effectué au cours des trois ou quatre mois hivernaux, sauf à des coûts accrus excessifs et, par suite, il faut prévoir des installations de compensation ou de stockage pour cette période, selon les exigences de l'usine. Toutefois, il convient de remarquer que Steep Rock et Caland Mines ont dragué de la tourbe pendant plusieurs années dans un climat ontarien très froid et ont exploité leur installations sans interruption pendant les hivers.

Pour faire fonctionner avec un rendement maximal une drague de 16 pouces dans la tourbe, il faut l'exploiter 24 heures par jour pendant toute la saison de dragage et il est par conséquent nécessaire que l'usine de traitement ait des dimensions importantes. On croit qu'il est peu pratique d'utiliser des dragues d'une dimensions inférieure à 16 pouces parce qu'elles sont probablement trop petites pour déchiqueter les racines et les arbres et consommeraient des quantités excessives d'énergie et de main-d'oeuvre pour pomper la tourbe à des distances appropriées. Les dragues de 30 pouces et plus sont des machines lourdes et leur utilisation ne peut être envisagée que pour draguer des dépôts de tourbe exceptionnellement étendus et profonds.

En résumé, cette étude indique que les dragues à tourbe doivent être capables d'excaver les dépôts profonds très étendus de tourbe combustible trouvés, par exemple, en Ontario. Les boues de dragage ainsi produites sont acheminables par des canalisations jusqu'à une usine de traitement productrice d'énergie qui, de préférence, utiliserait le procédé par voie humide.

I. A BRIEF SUMMARY OF STUDY FINDINGS

Over many years, cutter-suction dredging has been recognized as an economical means of excavating and transporting large quantities of silt, clay, sand, gravel and stone. These dredges consist of a large floating hull, supporting a rotating cutting head which, when lowered into the water, excavates a soils bank to 10 to 20 meters in depth. The rotating cutter produces a soils-water slurry of 10% to 30% solids by weight, which is sucked into an on-board pump, which in turn forces the slurry into pipelines to carry it distances of as much as 30 kilometers.

In eastern Canada, large volumes of peat have been moved by cutter suction dredge, but this is normally as an admixture with mineral soils. Cutter suction dredging of peat alone is quite a different exercise.

The structure of peat is unlike that of mineral soils, the specific gravity being less than half. The cell structure is such that it holds large quantities of water that can only be released with the application of heat. Such physical applications as grinding, squeezing or centrifuging reduce the water content but little. In short, when one pumps peat, one is pumping 10 to 20 weights of water per 1 of peat, whereas, with clay for example, the ratio could be 3 to 6 weights of clay per 1 of water. At the same time, pumping flexibility is limited to a maximum slurry thickness of 10% peat, by weight.

Peat deposits are relatively shallow and, for peat dredging purposes, should be selected of greater than 2 meters in depth, which occurrences will probably not exceed 6 meters maximum depth. Adequate supplies of water need to be available near the peat deposit, to replace the large volumes of peat and water to be pumped out of the deposit area to be delivered to an energy recovery process plant.

In situ fuel peat varies in composition from 85% to 97% water content and, as such, deposits to be sought for dredging should be of 90% water content or less, inasmuch as a 95% water content doubles the volume that will have to be pumped. Peat as macerated by the dredge cutter, is considered to be pumpable at 10% solids by weight, but some dilution at the cutter is inevitable. It is considered that a 7% or 8% slurry is deliverable to a process plant. Water levels in the dredge pond must be maintained at adequate depths to float the dredge and this probably requires dike ponding and pond water level control by additions from adjacent streams or lakes.

Peat dredging equipment must differ from that normally used. The dredge hull must be of shallow draft to minimize dredge pond dike requirements. In that peat deposits are shallow, a dredge must be capable of rapid horizontal movement. Also, the cutter must engage and cut full-time at the peat face, without loss of cutting action as the dredge moves forward, or as the cutter swings from side to side. Moreover, the cutter must be vertically controllable within narrow limits to continuously cut a full face of peat and, at the same time, avoid cutting into the bottom mineral

soils, which would contaminate the peat slurry. The cutter must be capable of leaving a smooth bottom without ridging and be capable of macerating roots and trees which grow in the peat or which were deposited there during peat formation. Storage surge ponds or tanks would probably be required to provide the process plant with a continuous feed, at times when the dredge is inoperative; for example, while dredge pipe is being moved, or repairs are being made.

To derive order of magnitude costs for a dredged delivery of peat to a process plant, three Ontario sites were selected for conceptual costing. (See Figure 1). However, there is little information available for large peat deposits in the detail necessary to perform a site-specific dredging feasibility study. As such, exploratory work has yet to be carried out. However, many large areas of peat exist in Ontario extensive and deep enough to be suitable for dredging.

Cost estimates for peat dredging, based on the conceptual basics described in this report, indicate that, with a 20-year dredge life, 1981 dredging costs would be in the order of $3.00 to $5.00 per dry tonne of peat, delivered to a process plant as a water slurry of 7% to 8% peat, by weight. Costs for peat, on the basis of 50% moisture, a fuel used for steam generation in Europe, would cost half that amount per tonne, delivered as a like slurry.

It is unlikely that peat dredging can be carried out in the three or four winter months, except at excessive, increased cost and as a consequence, surge or stock-piling facilities would have to be provided for that period, appropriate to the requirements of the plant. However, it should be noted that Steep Rock and Caland Mines dredged for several years in a very cold Ontario climate and consistently operated throughout the winters.

To operate a 16-inch dredge in peat, at maximum efficiency, operations must proceed around the clock through the dredging season and consequently a consuming process plant would have to be of substantial size. Dredge sizes of less than 16 inches are not considered to be practical as they would be too small to macerate roots and trees and would consume excessive amounts of power and labour to pump adequate distances. Dredges of 30 inches and more are ponderous machines and could only be considered for unusually extensive and deep peat deposits.

In summary, this study indicates that peat dredges should be capable of excavating from the deeper, more extensive deposits of fuel peat to be found, for example, in Ontario. The dredge slurries so produced are deliverable by pipelines to an energy producing process plant, preferably one which would employ wet processing.

Sites of Three Peat Deposits
in Ontario for Cost Estimates.

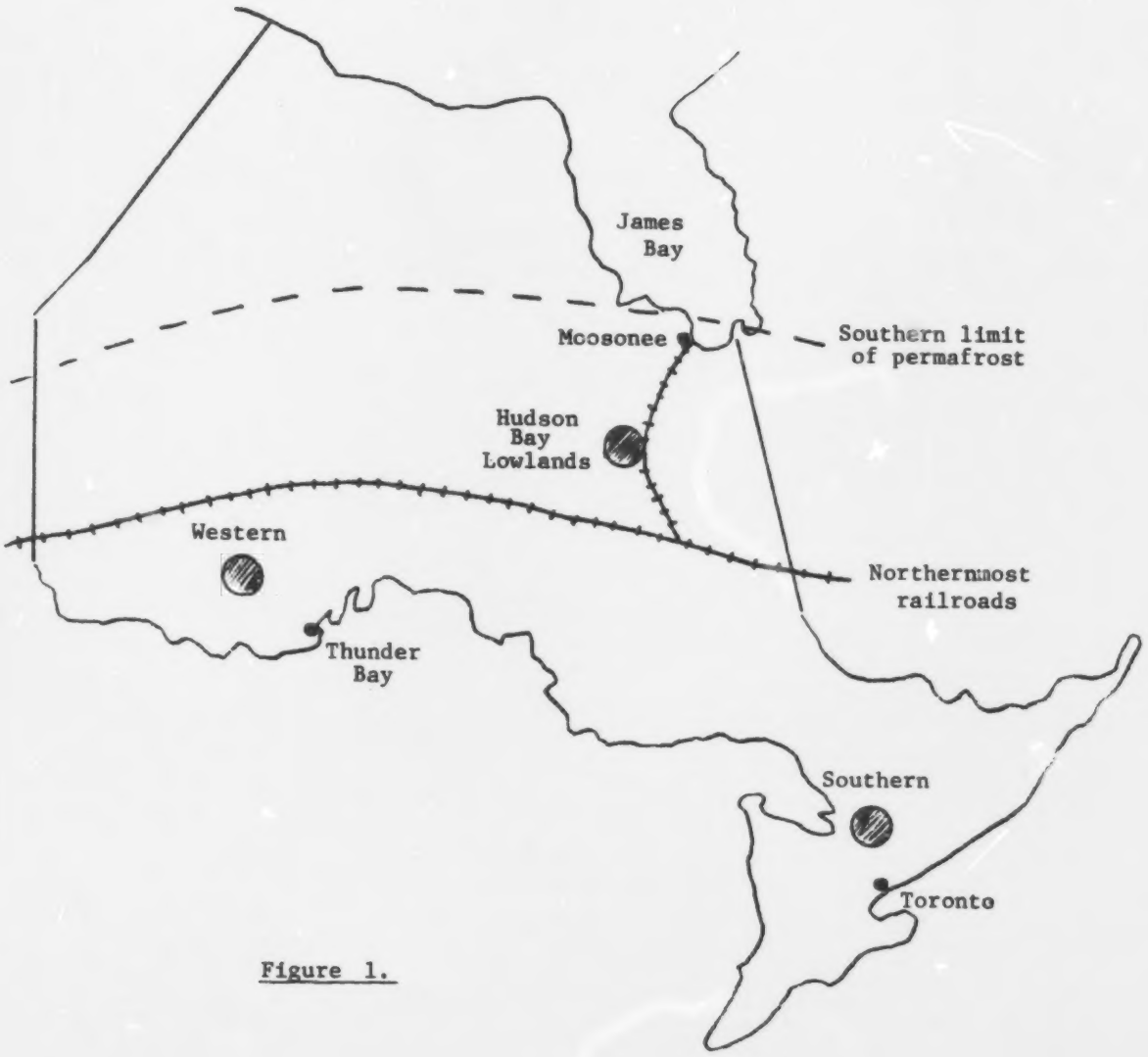

Figure 1.

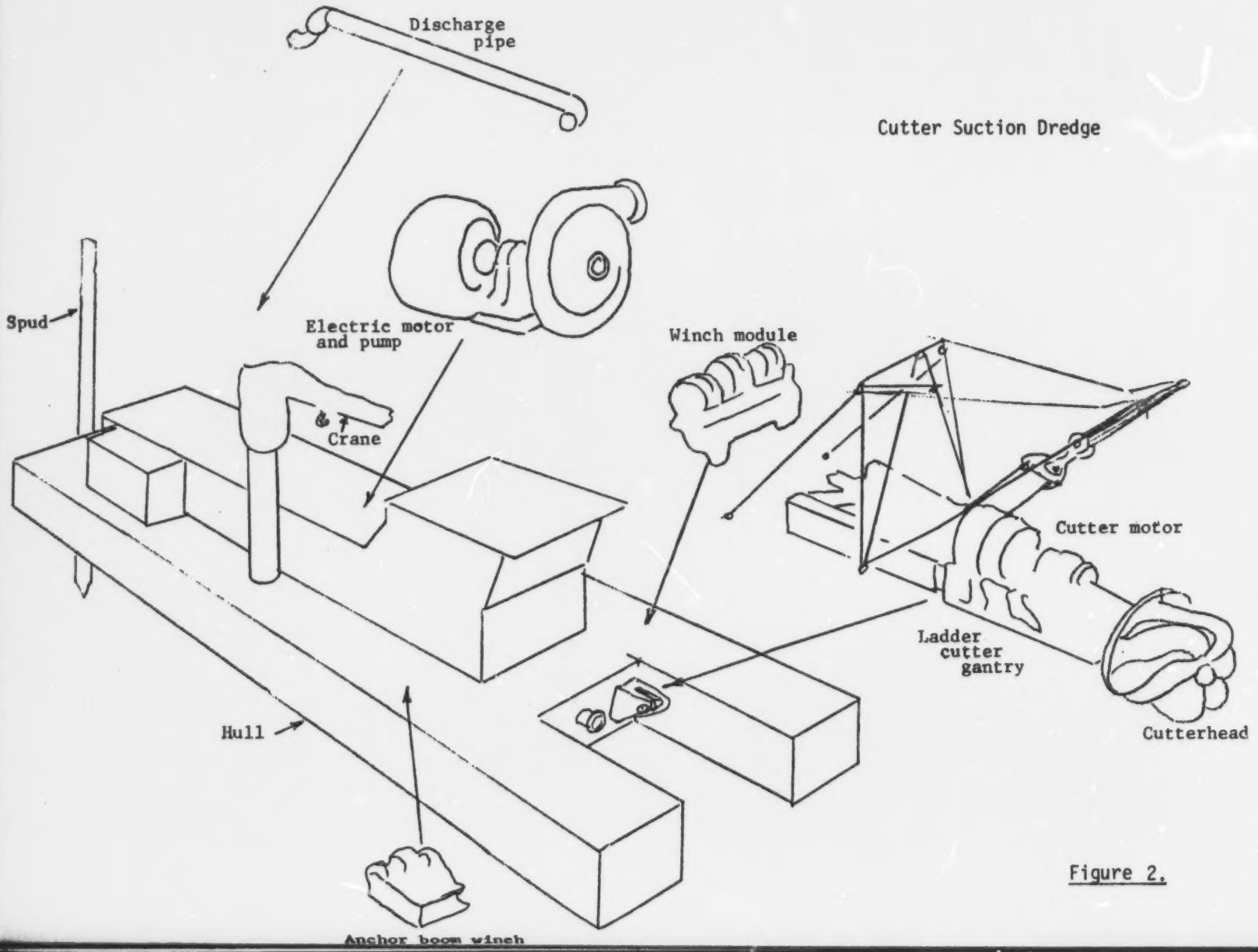
Discharge pipe
Cutter Suction Dredge
Spud
Electric motor and pump
Winch module
Crane
Cutter motor
Ladder cutter gantry
Hull
Cutterhead
Anchor boom winch

Figure 2.

II. TERMS OF REFERENCE

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1. STATEMENT OF WORK

You shall undertake a study of the technology and costs associated with the dredging of peat.

This study shall provide the following:

1. Description of site preparations, dredging operations and preliminary treatment (e.g., drying, stock-piling) of peat. This description shall include an evaluation of general operating constraints and shall cover both summer and winter operations.

2. Description of the production capacity, power requirement and other pertinent specifications for equipment required for the processes described in #1 above. Where possible, this description shall include both rated and actual performances.

3. Provision of the life cycle costs of the equipment described in #2 above; including such items as capital costs, maintenance costs, operating costs, expected lifetime, approximate time between failures and level of training required for operation.

4. Evaluation of the effect of scale on unit costs.

In order to perform this study, you shall:

- Provide such relevant information as is available from various personnel and records of McNamara Construction, a member of the Kesmark Ltd. group.

- Visit selected suppliers and attend peat seminars in order to update information on recently developed equipment.

2. PEAT FACT SHEET

North American dredgers have for years dealt in horsepower, U. S. gallons, feet and acres. For this reason, the original calculations for dredging were carried out in those terms.

For report purposes, metric conversions are given herewith and metric is used extensively throughout the report. In some instances, both terms may be given.

Metric Conversions

1 foot	-	0.305 meters
1 mile	-	1.609 kilometers (km)
1 acre	-	0.405 hectares (ha)
1 cubic yard	-	0.764 cubic meters (m^3)
cubic feet per minute (cfm)	-	cubic decimeters per second - 0.472 (dm^3/s)
1 U. S. gallon	-	3.785 litres (l)
1 ton	-	0.907 tonnes
1 horsepower (hp)	-	0.746 kilowatts (kW)
10^6 BTU/ton	-	1.16 GJ/tonne
3412 BTU	-	1 kilowatt-hour (kWh)

III. PEAT DREDGING BACKGROUND EXPERIENCE

Four projects are covered here as being considered of interest for the dredging of peat...for winter operations, in areas with inclusions of wood chips and methane gas, and areas with trees and roots on the surface and in the deposit.

1. PIPE LAKE - For Inco Mines at Thompson, Manitoba (1965). See Figures 3 and 4.

For the Inco Pipe Lake orebody, 11,500,000 m^3 of overburden were removed by a 30-inch cutter suction dredge. The soils consisted of sand, clay, gravel and included 1,500,000 m^3 of peat. There were three patches of permafrost, the largest being 180 m x 180 m. The peat pumped like water and the permafrost pumped after being ripped.

The operations required 17 months of dredging, carried out in the warmer weather - April 1st to December 1st to 15th.

To prepare for the operation, the 1,000-ton dredge was cut to pieces in Ontario and was then shipped to northern Manitoba, where it was rebuilt on dry land. A pump was installed in one arm of a nearby lake, and 4.8 km of pipeline was laid to the ore deposit to deliver water to the dredge pond and 4.8 km of pipeline was used to discharge dredged materials into another arm of that same lake. A dike was built around the dredge and water was pumped into the dike to float the dredge, following which operations began. (Figure 3).

The bog which covered the future mine area, showed little sign of trees on the surface, but as the dredging proceeded, numerous sizeable trees and roots were exposed, having been buried in the past and preserved where they fell.

The cost of the operation was $1.18 per m^3, or $0.29 per tonne, in 1965.

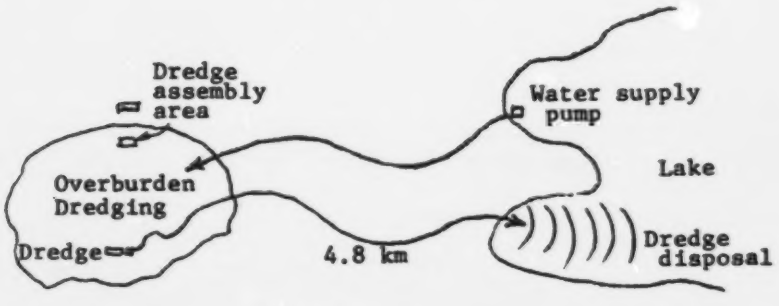


Figure 3.

Figure 4. Aerial View of Pipe Lake Dredging

2. STEEP ROCK, ONTARIO.

The excavation from Steep Rock and Caland steel orebodies removed 200 million m^3 of overburden by dredging, which required several years of operation, using two 36-inch cutter suction dredges. Operations continued throughout the winter, primarily by drawing down dredge pond water in the fall to expose to shallow freezing an area of silt and thus provide an ice-free dredging area for the winter. In the open pond where the dredge floated, ice breakers broke up new ice and draglines removed it from the pond. Were year-round peat dredging to be considered, the Steep Rock and Caland procedures should be studied.

3. QUEBEC CITY.

Dredging of the river bed was carried out to remove silt and bark that had been deposited over the years. The cutter suction dredge pumped these materials to extrude a slurry, which had the appearance of toothpaste. Methane gas in the deposit released by the cutter, rose to the river surface in huge boils.

Methane would undoubtedly occur in peat deposits to be dredged and would need to be considered from the standpoint of preventing that gas from breaking the dredge pump vacuum and for the possible extraction and use of methane from the dredged waters. Wood chips to be derived from roots and trees buried in the peat must be macerated and pumped by the dredge and could provide an added fuel for process plant use.

4. AFRICAN MANGROVE SWAMP.

Both in Nigeria and West Africa, dredges were employed to remove mangrove swamp peat and trees. The experience there is useful for assessing the action and production of their dredge cutter head and the cable methods they employed for moving through the swamp. If dredges can cut and pump mangrove swamp material, they can handle peat deposit material in Canada.

IV. SITE-SPECIFIC REQUIREMENTS FOR PEAT DREDGING

There are many requirements and restraints to be dealt with in this report, which will be covered more fully than in this section. Some of these are as follows.

- Topography of Peat Deposits and Underlying Mineral Soils.

Peat deposit topography must be suitable to contain dredge pond water 2 meters deep. Topographical survey information must include not only that of the surface of the peat, but that of the underlying mineral soils, as well as the subsoil drainage.

Subsoil characteristics must be determined to ascertain the usability of the land following peat dredging, i.e., for agriculture, forestry, biomass, fish culture or other use.

To provide a site for a process plant, solid ground should be available, preferably in a central location relative to the peat deposit to be dredged. Space may also be needed for wet or dry stockpiling facilities. Otherwise, floating plant and floating surge facilities must be provided.

- Dredge Pond Water Losses.

Water will be lost from the peat deposit dredging-process plant cycle in amounts of about 3 million m^3 per year, in a 24-inch dredge operation, and must be replaced from nearby lakes or streams to maintain the dredge pond level. (Figure 5).

- Peat Deposit Quality and Quantity.

The quantity of peat in a deposit must be adequate to supply a dredge with a continuous feed, over several years, and the quality of the peat must be such that it possesses an energy content, an ash content and a peat-to-water ratio to render it economically dredgable.

- Substantial site-specific engineering assessment must precede any peat dredging development.

Water Recirculation and Ponding

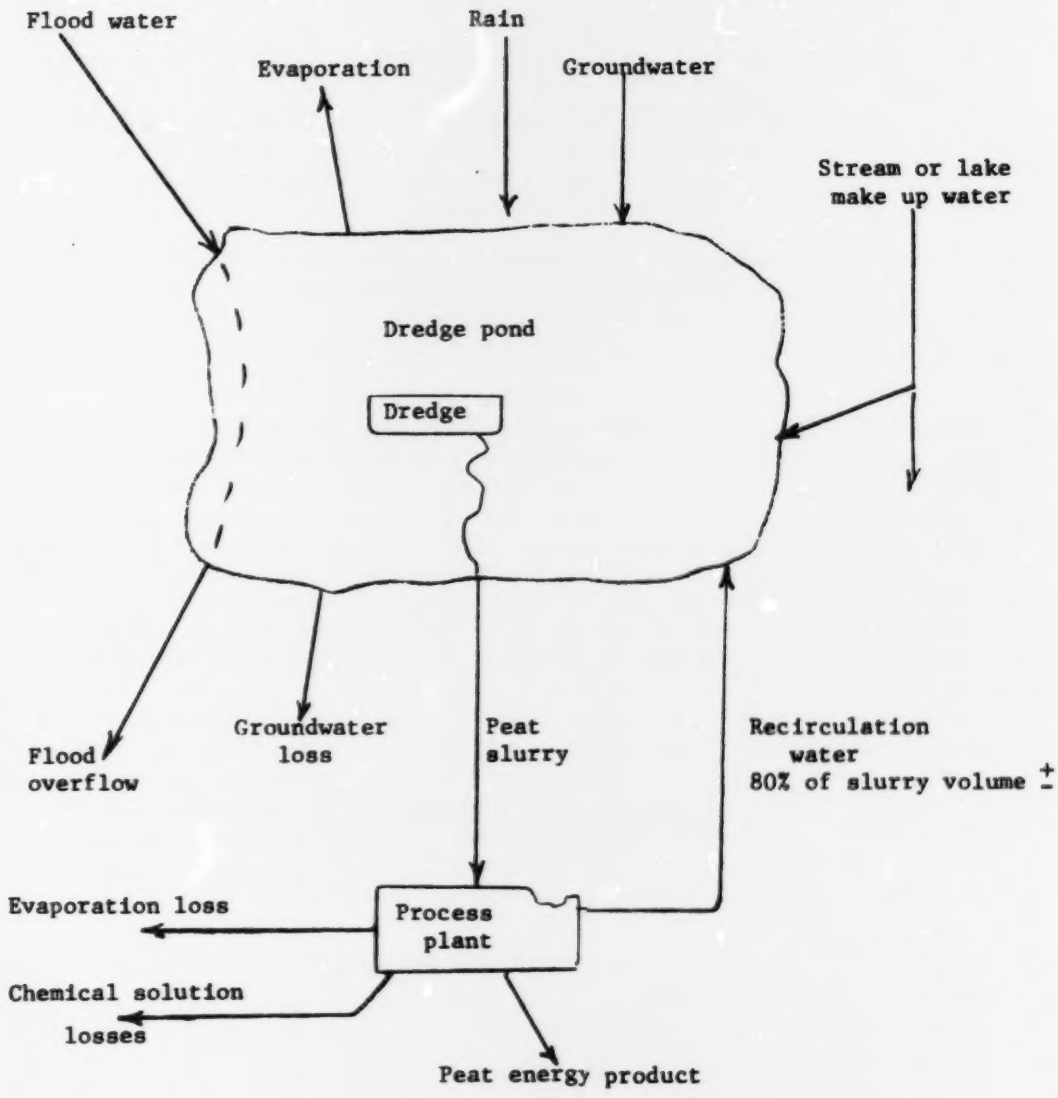


Figure 5.

V. RESTRAINTS TO THE DREDGING OF PEAT AND THEIR RESOLUTION

The Shallow Depth of Peat Deposits

As peat deposits are much more shallow than other types of deposits that would normally be excavated by a cutter-suction dredge, the standard dredge must be radically altered to increase its operating efficiency in peat by providing rapid horizontal movement and continuous cutting by the cutter-head. Such movement is obtained by the use of a single spud on the dredge and a triple-spudded barge. The dredge and barge would be linked with a rack-and-pinion gear driven by a DC electric motor. With this configuration, no cutting time need be lost in moving the dredge at the cutting face. Moreover, swing winches must be stronger and faster operating and spuds must be hydraulically operated and faster acting. Finally, a cutter must be used that cuts in both directions of swing and is capable of chipping buried wood, macerating the peat and leaving an unridged floor after dredging. (Figure 8).

Available Water Supply

River or lake supplies of water must be available near the peat deposit and be adequate to provide ponding to float the dredge and supply make-up water to replace slurry water lost in the process plant, which would no longer be available to be recirculated to the dredge pond. (Figure 5).

Discharge Waters from Process

Waters which are discharged from the dredging processing circuit, such as would occur when flood waters have to be expelled, must be environmentally acceptable downstream. Process plant water, for recirculation to the dredge pond must be such that it would not contaminate either the peat to be dredged or the soils remaining after dredging, when these soils are to be used for farming or other such purposes.

Dredge Cutter-head

The standard cutter-head used in dredging mineral soils is not suitable for dredging peat. As the dredge pivots on its spuds, the standard cutter-head cuts in one direction and on the return swing, it tends to walk over the ground without cutting while the dredge continues to pump water, but little peat. Moreover, with twin spuds, the cutter is not engaged at the face while the dredge moves forward. The standard cutter-head not only plugs with roots, trees and stones, but permits the dredge pump to plug as well, with a resultant excessive loss of operating time.

Proehl Cutter-head

The proposed Proehl cutter-head has been used on peat dredging jobs and found to be capable of cutting tree stumps and roots, up to one meter in diameter. The blades chip wood and roots to suitable sizes to be pumped. Also the rotating blades perform a screening action, rejecting large pieces of wood and stone. Both the peat and the wood are macerated to a degree. The Proehl cutter in peat would give higher production, with less down-time and require less power than the standard cutter. This cutter permits bank and bottom trims to a much greater degree of smoothness, with little ridging. (Figure 6).

Winter Operations

Winter operations are not considered feasible, except at considerable added expense. Air-bubbler systems are of no value for keeping a dredge pond open, as dredge movements are too rapid. The winter shut-down time will vary with the climate, but at Thompson, Manitoba, where the climate is rigorous, it was 3½ to 4 months. However, at Steep Rock and Caland Mines, dredging continued throughout the winter months by exposing the area to be dredged by pond draw-down and by breaking and dragline removal of pond ice.

Permafrost

Permafrost in peat can be dredged after the frozen peat has been loosened by a bulldozer.

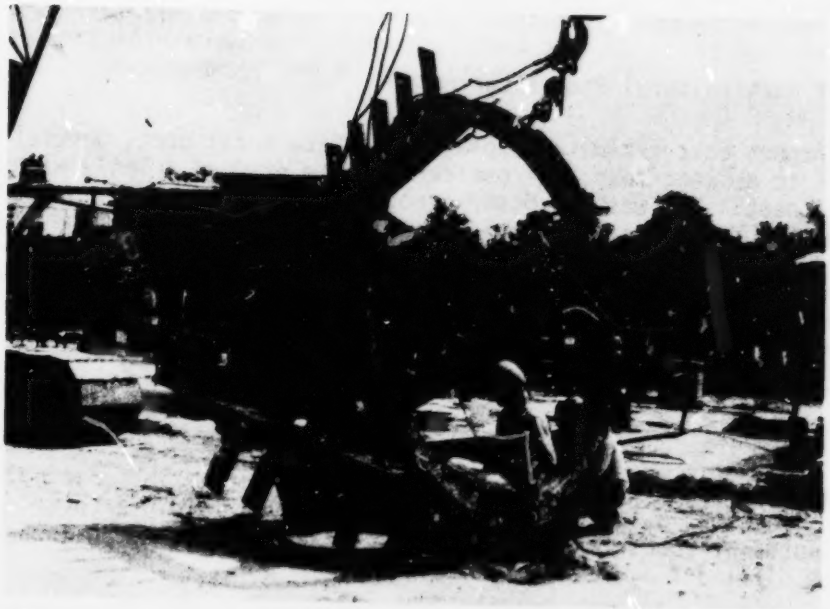
Dredge Pipe

The study costing is based on the use of steel pipe to carry slurries from the dredge to the process plant. Aluminum pipe may be feasible as an alternative, at a much greater pipe cost, but it provides lighter loads for handling manually. For example, if dredge pipe is to be placed across the bog on wire mats, the pipe sections must be light enough to be moved by hand. Floating pipe should be supported by steel floats, rather than styrofoam, which is subject to excessive damage.

Gravity Separation of Mineral Soils

Due to the fact that the mineral soils contained in the peat deposit have substantially higher specific gravities than peat and, because they will drop out of suspension at pipeline velocities of less than 12 feet per second, this factor can be employed to remove unwanted sand, gravel and balled clays and to dump them into a pond area already dredged out. (Figure 9).

Proehl Cutter-head



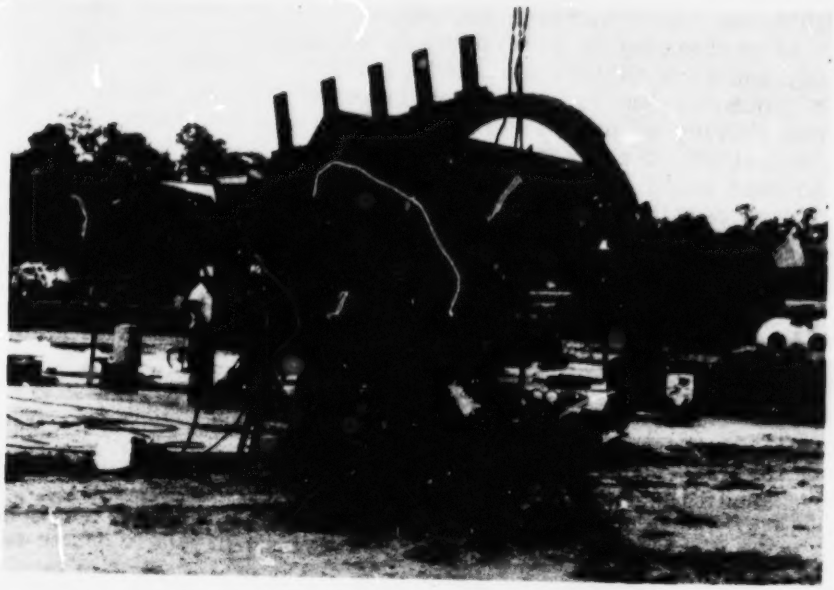


Figure 6.

Low Peat Content Slurry Controlled by Sensor Valves

Sensor or remote-control valves can be used to dump water back into the dredge pond, or low peat content slurry into the surge pond where, by decantation, it could be further concentrated. (Figure 10).

Sphagnum Horticultural Peat (Peat Moss)

In the report cost estimates, sphagnum horticultural peat, generally referred to as peat moss, is considered to be dredged jointly with the fuel peat. The western Ontario bog in this study, for example, has a depth of 0.3 m of horticultural peat overlying an average of 2.0 m of fuel peat. With dredge pond flooding, some of the light surface materials will float away. In the case of the western Ontario peat deposit, it would not appear to be economical to remove the horticultural peat separately.

Portability of Dredges

Dredges can be built to be sectionalized for transport by road or rail. However, on site, a 16-inch dredge can be skidded in winter over frozen ponds or roads to new locations. Large dredges of 30 inches and more are difficult and expensive to move.

Slurry Settlement Concentrating

Pulping of peat by fine grinding, as a part of dredge pond activity, is possible and could increase the pumpability of thicker slurries. The cost of processing is considered to be beyond the capabilities of this study and such matters as seiving, pressing, fine-grinding, drying or other concentration is considered as being done by others. Shore pond concentrating of peat slurry might be given consideration. In such an operation, the dredged slurry would be pumped to shore ponds where the peat would settle out and the decantation water would return by gravity or pumping to the dredge pond. Recovery of the settled peat could be by clamshell, dredge or other means. (Figure 7).

Equipment other than the Cutter-suction Dredge for Wet Mining of Peat

Various other types of equipment were considered for mining peat, such as - draglines, clamshells, backhoes and bucket dredges. Each was rejected for large-scale production, for various reasons. Draglines tend to channel the excavated peat and would dig mineral soil as well. Clamshells are slow in operation and lose part of the load on each swing. Backhoes do not have enough reach. Each of these three machines

has limited movement on the water or on the peat surface. Bucket dredges are cumbersome and inefficient at shallow depths. Conversely, the cutter-suction dredge works well in all but the coldest weather; it sucks away the excavated material, so that it does not ground the dredge with stirred or spilled peat, roots and wood. It is a machine that takes advantage of the muskeg waters.

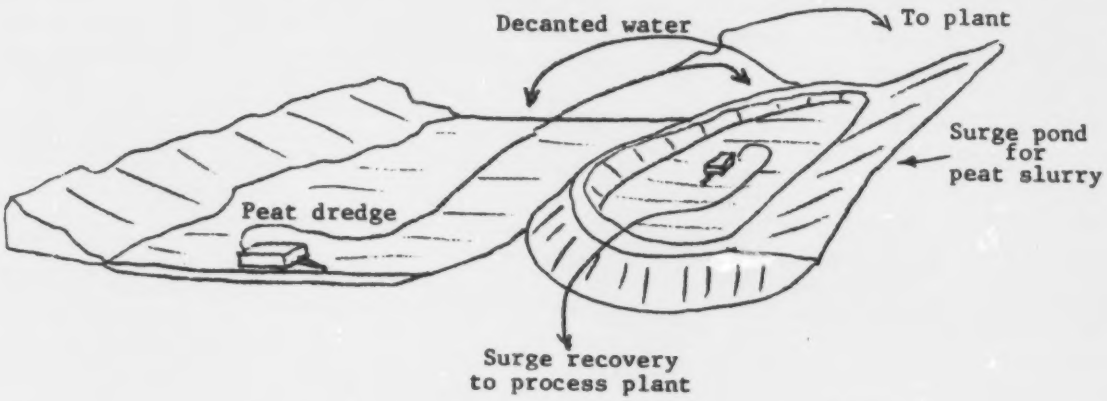


Figure 7 .

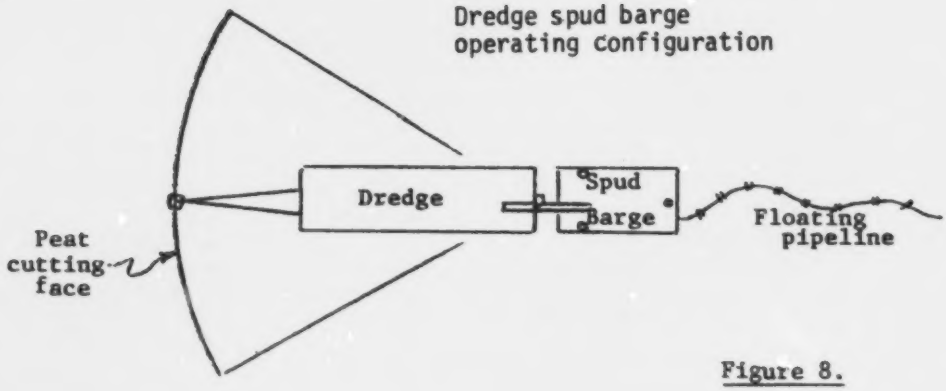


Figure 8.

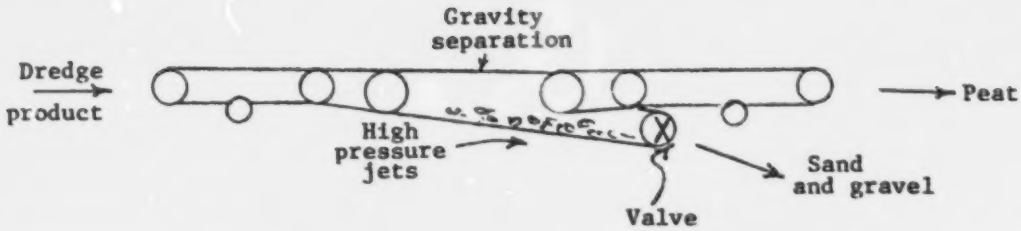


Figure 9.

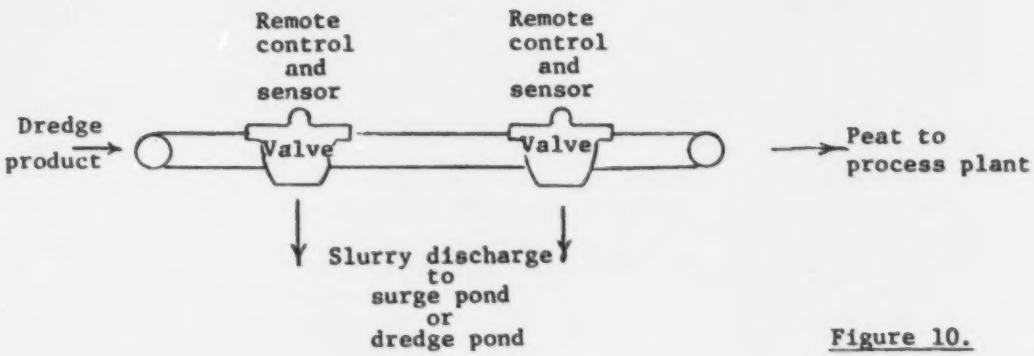


Figure 10.

VI. COSTING OF PEAT DREDGING FOR THREE SITES

Dredge Operations Maximized for Costing

Only two dredge sizes (16-inch and 24-inch) were costed and these were considered as being operated at maximum capacity. Dredges must be designed and built to sizes and horsepower requirements to suit the characteristics of the peat deposit to be dredged. As is described in the following text, cutter-suction dredges smaller than 16 inch discharge are not considered to be suitable dredges smaller than 16 inch discharge are not considered to be suitable for peat dredging, as smaller units would be unable to pump economically to suitable distances nor could they chip and macerate buried trees and roots contained in the peat deposit.

Special consideration would have to be given to dredges over 24 inch discharge, as they are ponderous to move rapidly across shallow-depth peat deposits and are heavy and costly to move between sites.

It is further suggested that cutter-suction dredging of peat should not be considered for projects designed to produce, for example, electricity of less than 100 megawatts. Smaller production rates, with a 16-inch dredge would necessarily sacrifice dredge efficiency.

Cost estimates have been made for peat dredging of three peat deposits in Ontario as follows (Figure 1):

1. Western Ontario peat deposit (See P. 21).
2. Hudson Bay lowlands peat deposit
3. Southern Ontario peat deposit

1. WESTERN ONTARIO PEAT DEPOSIT

A peat deposit was selected west of Thunder Bay containing some 10,000 hectares of fuel peat, averaging over 2 meters in depth. This deposit had been explored and reported on by the Province of Ontario as the Meinzinger bog (Page 21 and Figures 11 to 15 incl.).

Some peat sampling has been carried out at this deposit and aerial and satellite pictures follow. Topographical maps are quite inadequate for the design of water control dikes, as the maps are only contoured at 50-foot intervals.

The dredging plan for this peat deposit calls for the dredging of peat from a series of diked ponds, with the product to be delivered to a central processing plant, a maximum distance of 7 kilometers. The dredge costed is a 24-inch discharge cutter-suction dredge and the pipeline is of 24-inch diameter. A shore surge facility is designed to accommodate daily dredge shutdowns. However, the three-month winter shutdown would be provided for by dry storage of fuel peat, by others. It is considered that the dredged peatlands could eventually be used for biomass production.

Other design considerations are as follows:

i) Life - 20 years, with a plant move in 10 years.

ii) Topography - land fall north to south - 15 meters in 10 kilometers.

iii) Yearly area required for dredging - 840 hectares.

iv) Average peat thickness - 2.3 m, of which 2.0 m is to be dredged, to leave 0.3 m on the bottom.

v) Water supply - to be diverted to diked ponds from a river and lake system to the immediate west of the peat deposit.

vi) Process plant, wet surge pond and dry fuel peat storage - centrally located to the west of the peat deposit.

vii) The dredge - a 24-inch cutter-suction dredge, pumping through a 24-inch pipeline 2 to 7 km in length.

viii) Production season - 9 months per year, operating 24 hours a day, of which the dredge pumps slurry 18½ hours per day using a 65% efficiency pump.

Western Ontario Peat Deposit

MEINZINGER TOWNSHIP

Location

The Meinzinger deposit occupies the western half of the township and extends beyond the township limits for 3 km to the north and 4.4 km to the south. The settlement of Graham on the Canadian National Railways lies 7.2 km to the northeast The City Thunder Bay lies 114 km to the southeast.

Access

The road to Graham leaves Highway 17, 14 km west of Upsala and passes 1.2 to 6.4 km west of the deposit. A road extending west from Graham passes 0.8 km to the north. Highway 17 and the Canadian Pacific Railway, cross the southwest end.

Area

The Meinzinger deposit is the largest bog examined and is connected with Deposit 25: Trewartha Township at its southwest end. It comprises an area of some 3850 ha of which 2050 ha in the southern part were sampled at 10 sites.

Surface

The surface is undulating. The central part is saturated and supports a growth of eriophorum on a sphagnum carpet. Widely scattered tamarack and a few spruce averaging 0.3 m to 1 m in height are present.

To the northeast and southwest the surface is drier and is characterized by a hummocky sphagnum surface with labrador tea (ledum) and minor eriophorum. The drier area to the northwest in the vicinity of sites 8 and 9 has a sparse, 1 m tall tree growth. The area to the southwest between sites 3 and 4 is more forested with spruce trees averaging 3 m in height.

Depth

The average depth as determined from the sample sites is 2.29 m. The maximum depth of 4.3 m was obtained.

Nature of Peat

The sphagnum surface layer is 0.2 to 0.5 m thick. The underlying peat is relatively uniform material with a von Post humification factor generally of H5 to H7.

The material underlying the peat varies from grey to black clay and sandy clay through brownish silty sand to light grey sand.

The ash content varies from 4.5 to 13.4 percent and averages 8.8 percent. The moisture content varies from 86.2 to 93.8 percent and averages 90.4 percent.

The main characteristics of the peat are tabulated below.

	Range	Average
Water percent	86.2-93.8	90.4
Ash Dry percent	4.6-13.4	8.8
Wet Vol. Dry Wt. gm/cc	.08-.13	.11
Cal. Val. Kcal/Kgm	2255-5611	4803
S percent	.1-.34	.19
P percent	.04-.07	.06

Drainage

This large deposit would require elevations over a broad area to assess the drainage requirements. Natural drainage is towards the southwest via Baker Creek and south into the Firesteel River 7 km distant. A creek also drains out of the south-central part into the Firesteel River. The estimated drop in elevation to the Firesteel River is about 15 m.

Internal drainage as indicated by flark zones is from the north into the south-central saturated part of the deposit.

There are no visible creeks draining into the bog.

Comments

Approximately 53 percent of the total open area of the Meinzinger deposit was examined. Consequently the potential peat resource of this deposit presented in Table 5 is considerably less than the total potential. This deposit in conjunction with the adjoining Deposit 25 in Trewartha Township and Deposit 24 in Stedman Township, 5 km distant, represents the largest potential sources of peat fuel in the areas examined.

Roots were not encountered in the reconnaissance sampling. This, combined with its large open area and easy access, are factors favouring its development. More extensive and more detailed sampling, drainage studies, quality tests, and economic studies are required to provide a proper assessment both with respect to reserves and development.

Three-phase electric power is available at Upsala 19.4 km to the east. Upsala is a pulp-cutting centre and gas pipeline base. The gas pipeline passes 4 km south of the deposit.

(Extract from "Some Peat Moss and Peat Desposits in Selected Areas"
by R. Bruce Graham, Ontario Ministry of Natural Resources - 1979)

Air photograph, Deposit 29, Meinzinger Township

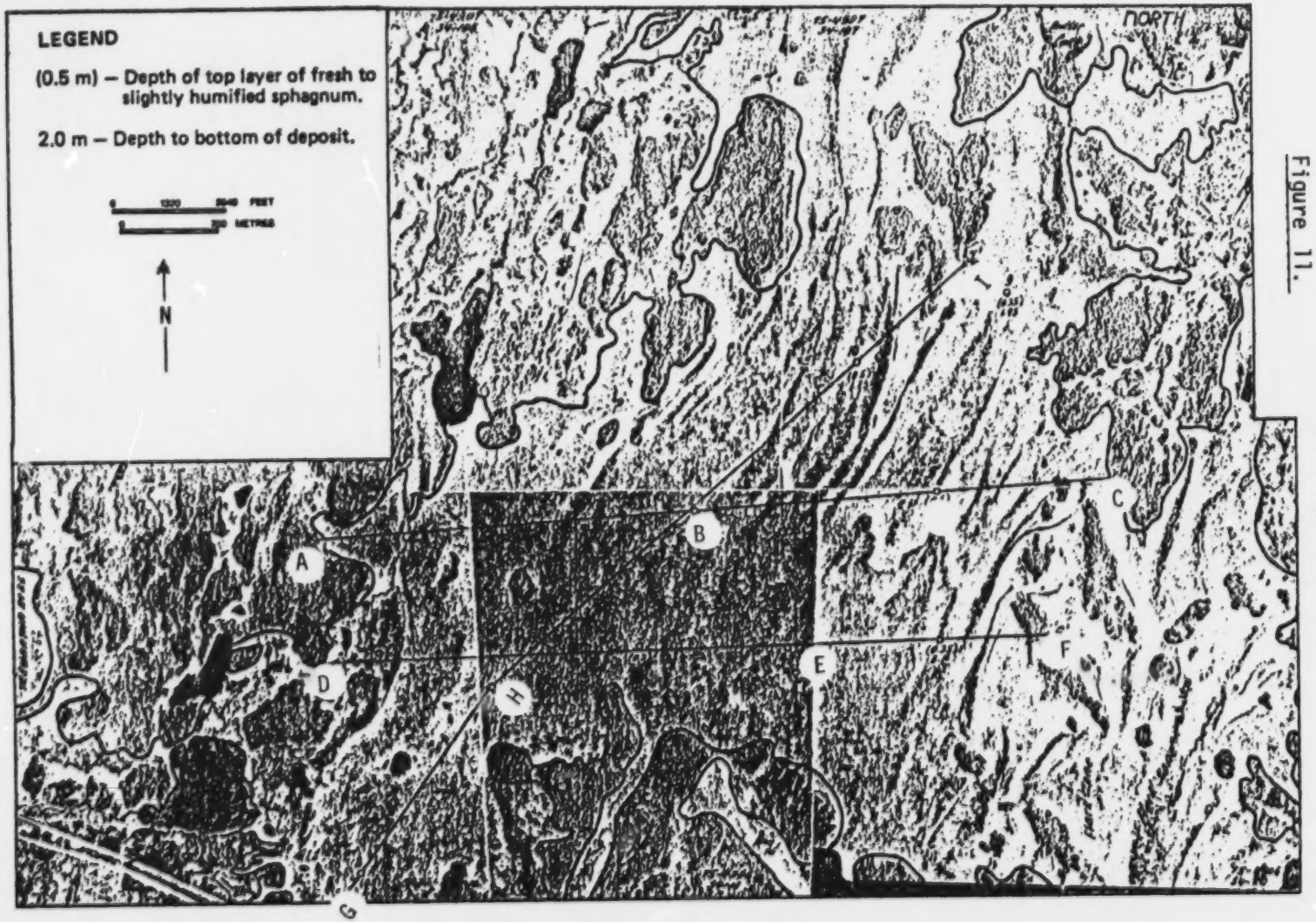
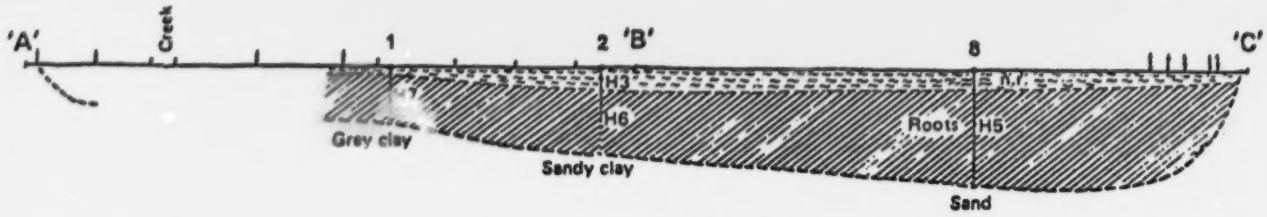
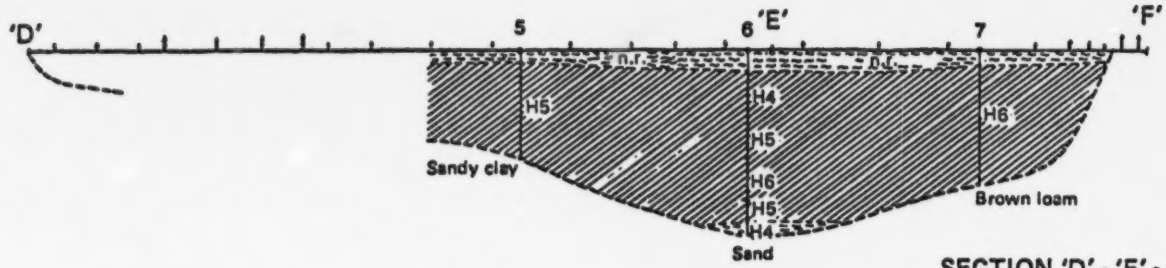


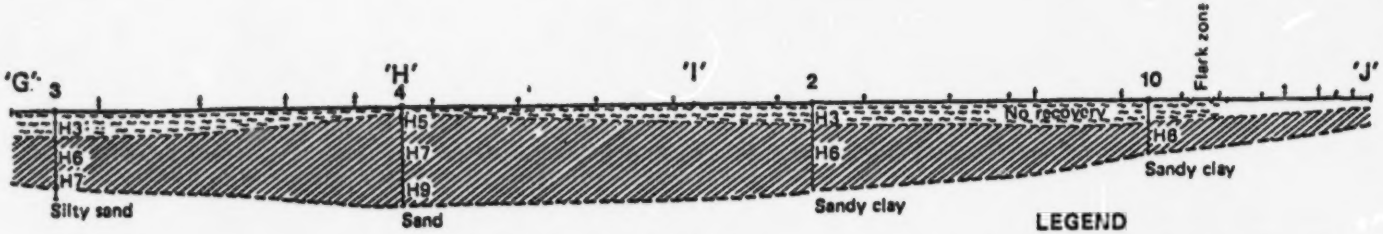
Figure 11. Meinzinger Peat Deposit



SECTION 'A' - 'B' - 'C'

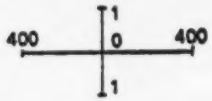


SECTION 'D' - 'E' - 'F'



SECTION 'G' - 'H' - 'I' - 'J'

SCALES IN METRES

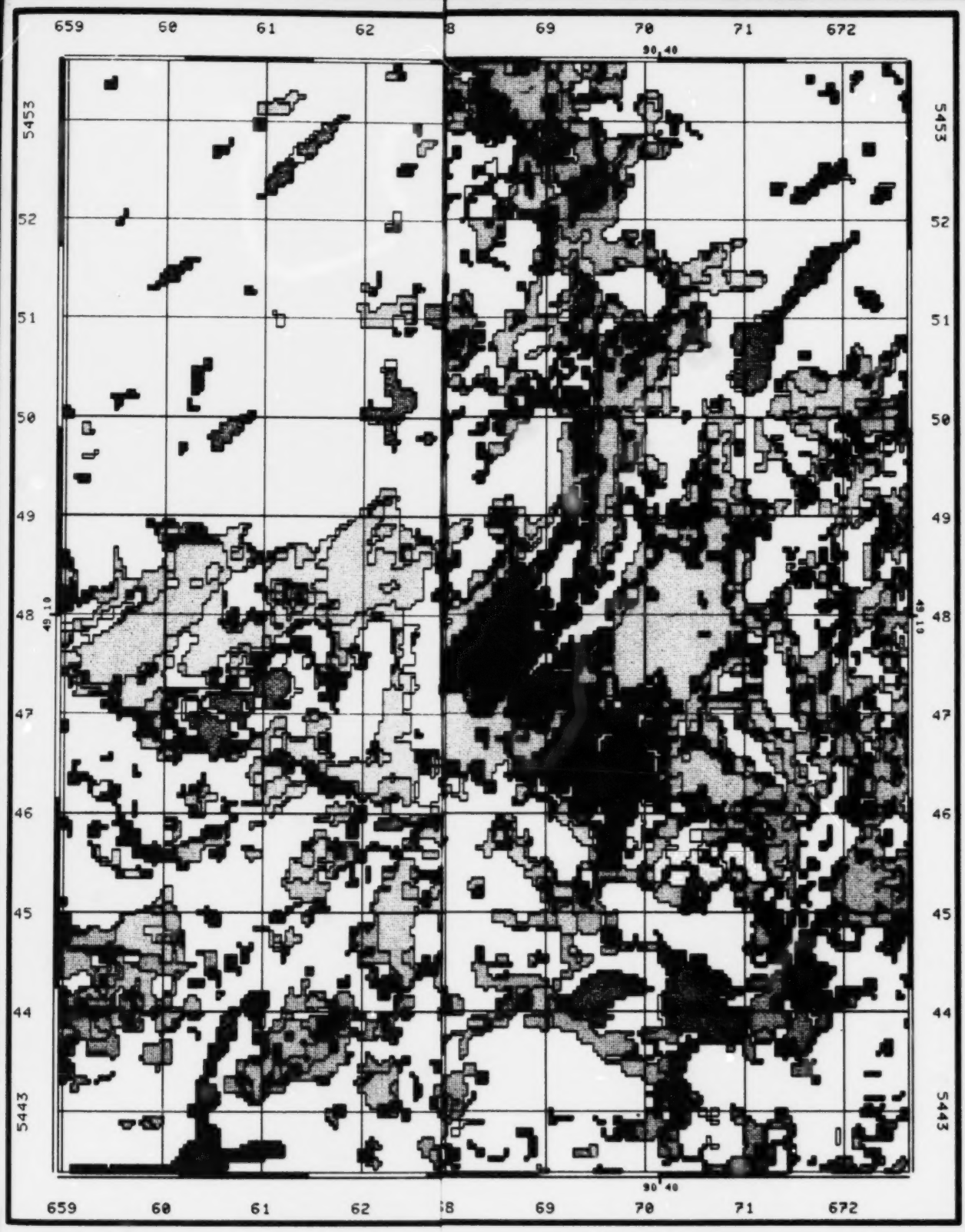


LEGEND

- Open grassy area on sphagnum
- Dense tree clumps
- 1m Trees
- 2 - 2.5 m Trees
- ≈≈ Sphagnum
- /// Peat
- H6 Humification, von Post Scale
- n.r. No recovery

Cross sections, location shown on Photo 32, Deposit 29: Meinzinger Township. (1978).

Figure 12.



WATER

SHRUB-RICH BOG

OPEN SPHAGNUM BOG

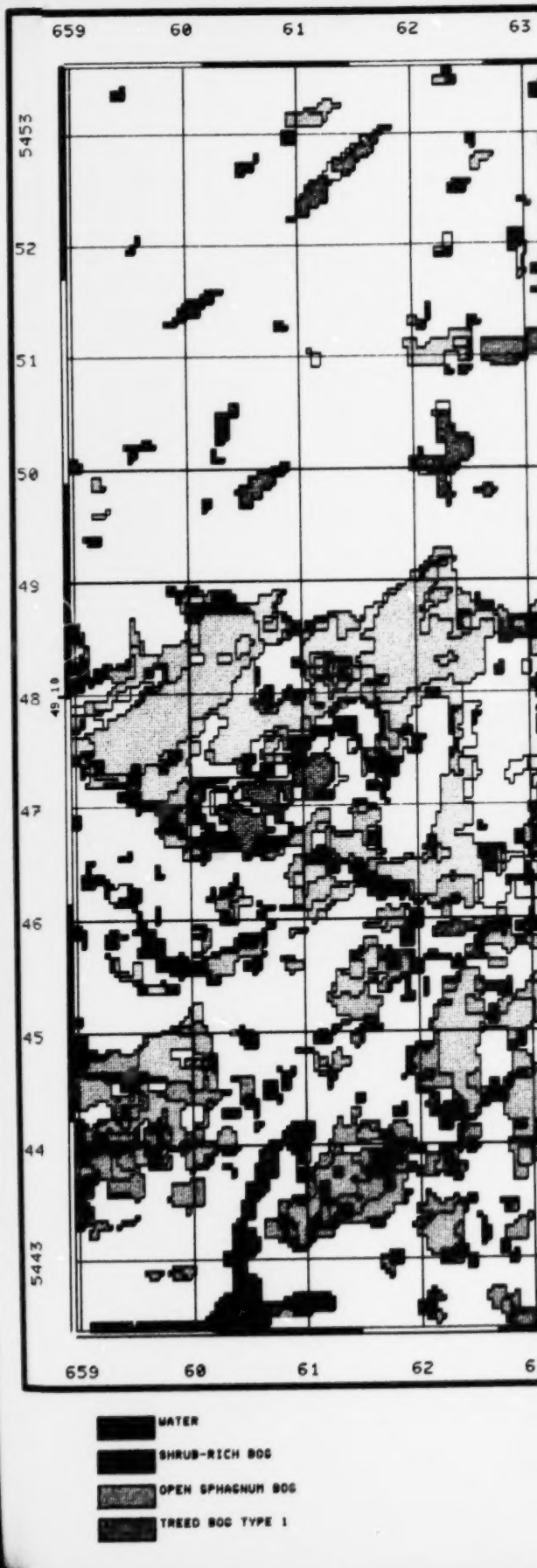
TREED BOG TYPE 1

ANALYSIS

TREED BOG TYPE 2 MIXED WITH FEN

FEN WITH OPEN WATER

TREED BOG TYPE 3


659
60
61
62
63
5453
52
51
50
49
48
49.10
47
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5443
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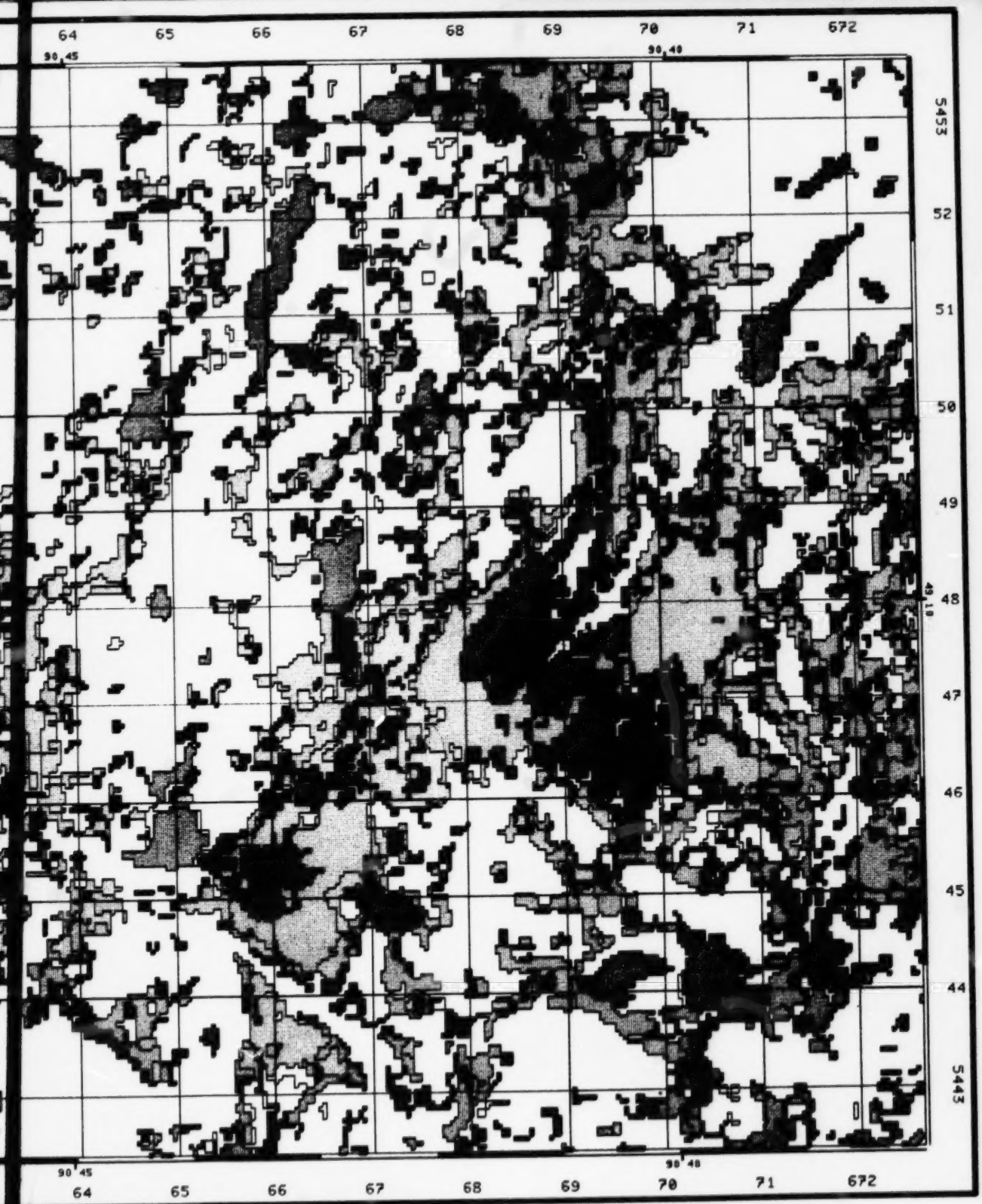
62
6
WATER
SHRUB-RICH BOG
OPEN SPHAGNUM BOG
TREED BOG TYPE 1



TREWARTHA BOG

LIMINARY ASSESSMENT OF THE TREWARTHA BOG BASED ON LANDSAT DATA ANALYSIS

PREPARED BY S. PALA AT O.C.R.S. (MNR)

SCALE 1:50000

MULTICLASSIFIED UNCLASSIFIED

TREED BOG TYPE 2 MIXED WITH FEN

FEN WITH OPEN WATER

TREED BOG TYPE 3

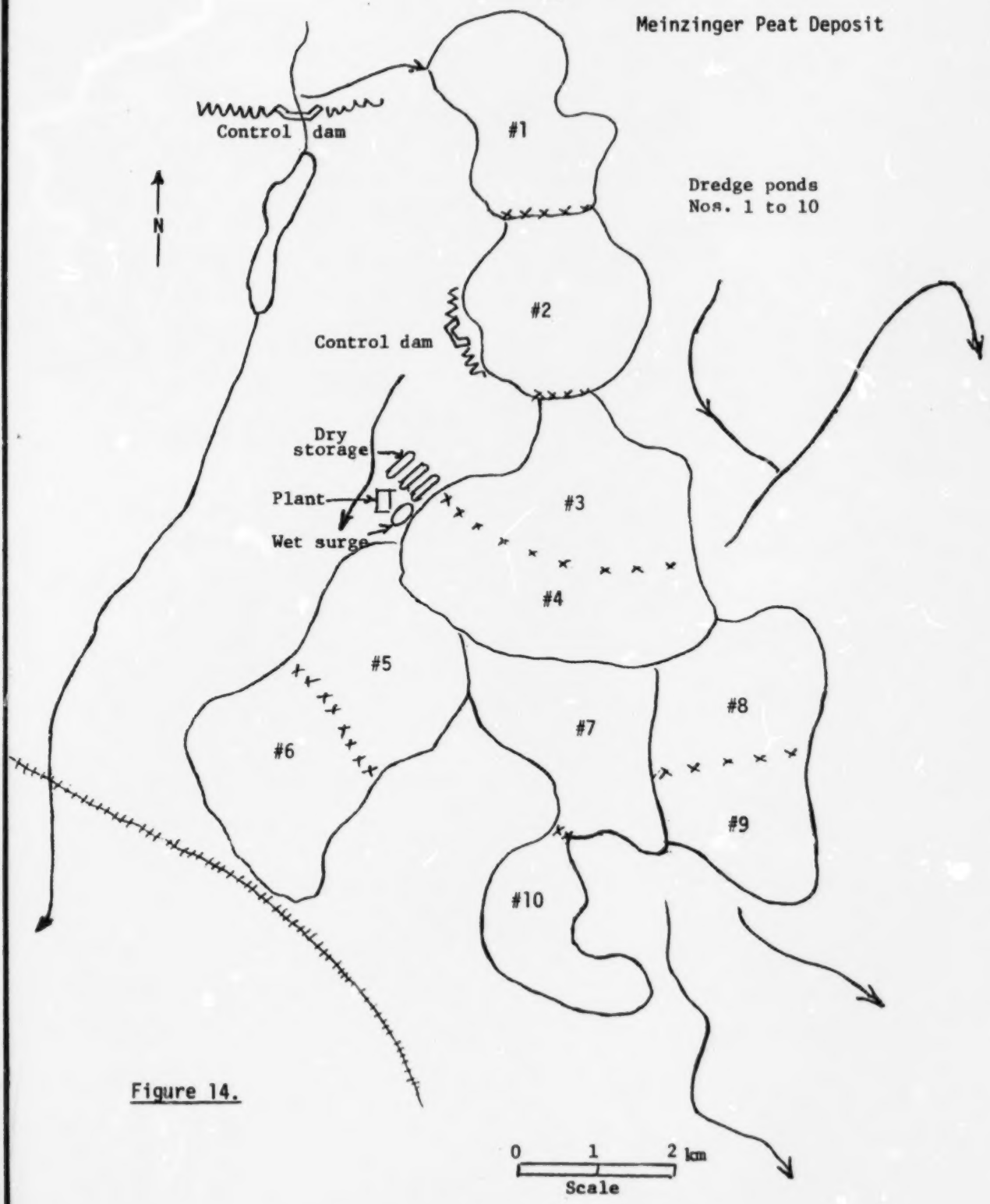
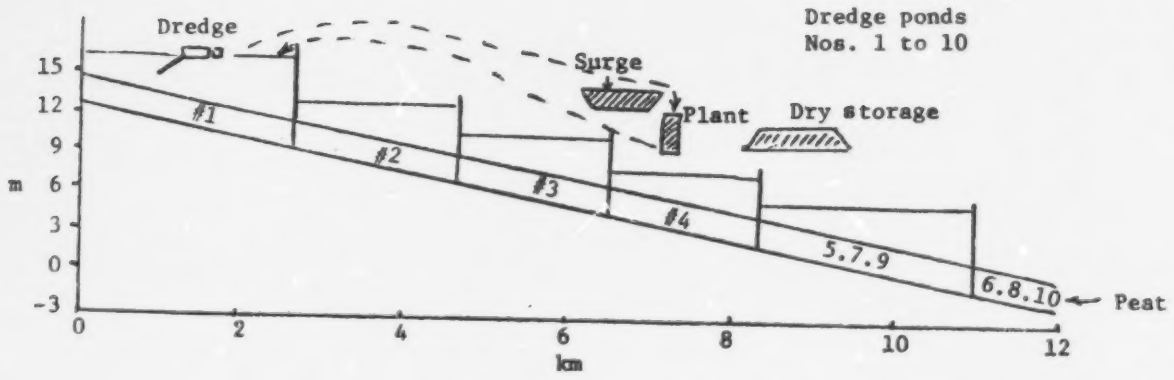

Meinzinger Peat Deposit
Control dam
#1
Dredge ponds
Nos. 1 to 10
N
#2
Control dam
Dry
storage
Plant
Wet surge
#3
#4
#5
#6
#7
#8
#9
#10
0 1 2 km
Scale

Figure 14.

Meinzinger Peat Deposit



Dredge Ponds

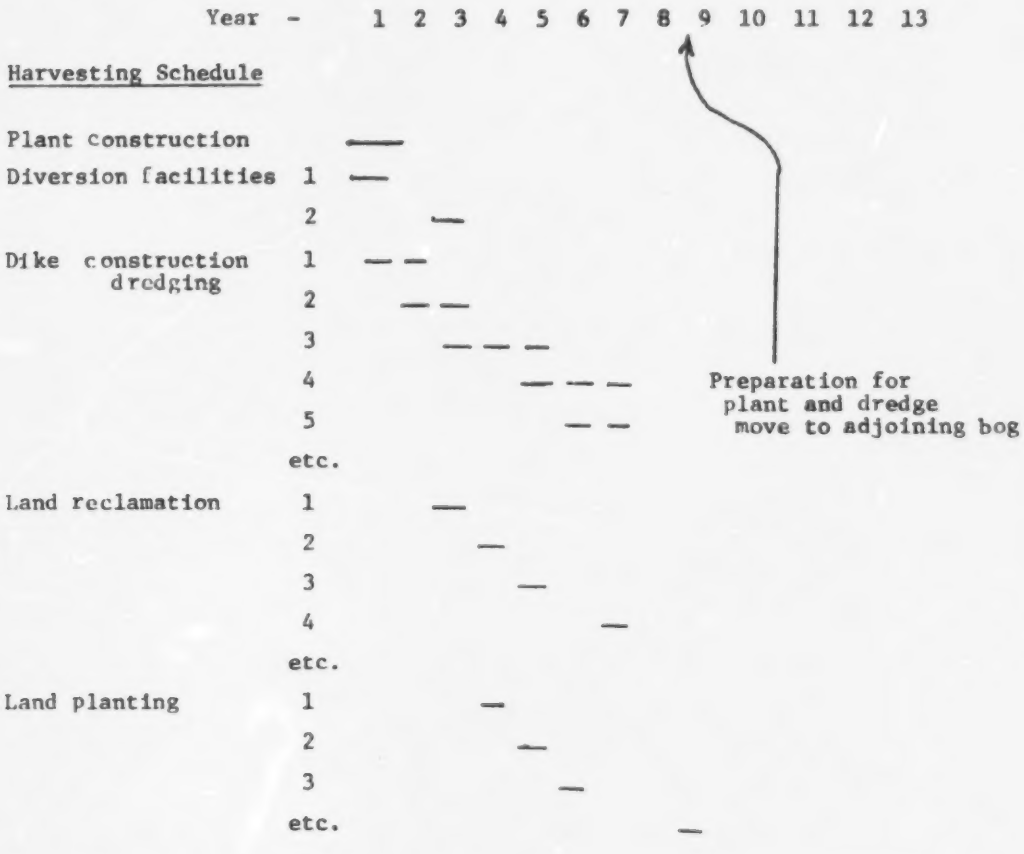


Figure 15.

24-inch Dredge - 24-inch Pipeline

- Pumping at 12 feet per second velocity
- In situ peat 90% water by weight
- Peat varies in specific gravity from 1 to 1.5, but for this deposit, with gas inclusion and a variable decomposition with depth, the average will be considered to be 1.0 specific gravity.
- Peat, as macerated by the Proehl cutter-head, pumps like water, but due to partial engagement of the cutter at the peat face, 25% water is considered as being added to the peat slurry.
- Lost time in a 24 hour dredging day is 5½ hours, including loss of cutting time at the face, dredge hook-up time, loss due to dredge anchor moves, re-positioning the dredge between lateral cuts, adjustments for process plant shutdowns, and maintenance shutdowns. This leaves 18½ hours per day when the dredge is actually cutting.

The 24-inch dredge pumping at 12 ft. per second velocity through the dredge pipe, = 3,839 m^3 per hour

Representing - 3,071 m^3 per hour of in situ peat
or - 307 tonnes (dry) peat per hour

In 9 months (30 days/month - 18½ hours cutting per day) -

dredge cuts - 1.5 x 10^7 cubic meters in situ peat

to produce - 1.5 x 10^6 tonnes dry peat

requiring - 765 hectares of peat 2 m deep
say, - 840 hectares.

Dredge and Pipeline Head Losses:

	Pipe length	
	3 km (feet)	7 km (feet)
Dredge suction loss	20	20
Dike rise	20	20
Plant and surge pond rise	40	40
Pipe friction	200	470
	280	550
	(85.4 m)	(167.8 m)

Horsepower Required:

	Pipe Length	
	3 km (HP)	7 km (HP)
On board dredge -		
Dredge pump 65% efficient	1300	1300
Cutter	500	500
Winches	200	200
Welders, light & heat	100	100
Spud barge	200	200
	2300	2300
Booster pump on shore -	--	1300
Total Horsepower	2300 (1716 kW)	3600 (2686 kW)

Consider the deposit to provide 10 years' supply, before moving to a neighbouring site.

Capital Costs

	Life (years)	Capital	Yearly
Dredge move-in	10	$ 500,000	$ 50,000
Dredge	20	3,000,000	150,000
Spud barge	20	400,000	20,000
Booster pump	20	600,000	30,000
Powerlines, cable & barge	20	260,000	13,000
Auxiliary equipment:			
Tugs	20	400,000	20,000
Floating backhoe	20	260,000	13,000
D-6 Bulldozer sideboom	5	120,000	24,000
Crew boats	20	60,000	3,000
Work barges	20	320,000	16,000
Service trucks	6	70,000	12,000
5 pickup trucks	3	60,000	20,000
Swamp buggies	5	200,000	40,000
Welders small tools	10	60,000	6,000
Buildings - mechanical, office, dry, warehouse	20	500,000	25,000
Spare parts on hand	10	200,000	20,000
Total		$7,010,000	$462,000

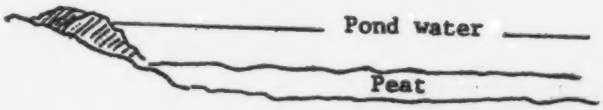
Operating Costs

	Life (years)	Capital	Yearly
Pipe: Floating @ $60/ft. - 3000 ft.	4	$ 180,000	$ 45,000
Shore @ $30/ft. - 7500 ft.	4	225,000	56,000
Shore @ $30/ft. - 10500 ft.	6	307,000	50,000
Horsepower:			
3 km @ $90/HP year - 2300 HP = $207,000			
Add - 4 km to 7 km - 3600 HP = $324,000 - for half time = $162,000		--	369,000
Crew:			
3 shifts (5 men) = 15 1 shift (10 men)= 10 25 men 8 hours/shift, 30 days/month, 10 months/year -			
2400 hrs. x 25 men @ $25/hr. (including overtime & social legislation) Includes maintenance labour.		--	1,500,000
Camp: @ $30/man-day		--	225,000
Maintenance materials:		--	300,000
Clearing: Little clearing is required with the Proehl cutter to remove merchantable trees; cutter will chip roots & tree trunks buried in the bog.			
840 hectares @ $100		--	84,000
Pond water recirculation:			
This will be accomplished half-time by gravity.			
Pumping 36-inch pipe @ $50/ft. - 4 km (and pump)	10	655,000	66,000
Horsepower - 130 HP half-time $90/HP year		--	6,000
Total		$1,367,000	$2,701,000

Western Ontario Peat Deposit

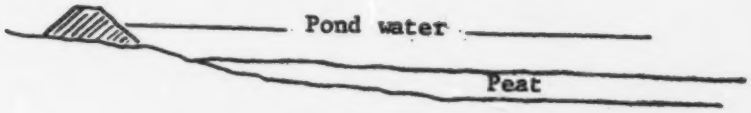
Per km

1. Shore dikes - shallow.



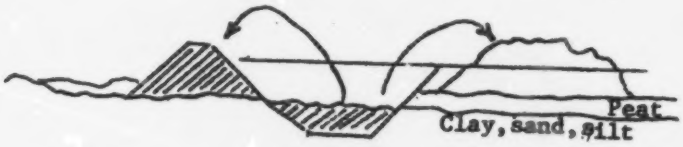
5 m^3 per lineal meter = 5,000 m^3

2. Shore dikes - 4 m high.



20 m^3 per lineal meter = 20,000 m^3

3. Cut-off dikes in peat - 2½ m depth.



400 s.f. peat
200 s.f. clay/sand
600 s.f.

60 m^3 per lineal meter = 60,000 m^3

4. Cut-off dike in peat - 3½ m depth.

800 s.f. clay
500 s.f. peat
1300 s.f.

130 m^3 per lineal meter = 130,000 m^3

Western Ontario Peat Deposit

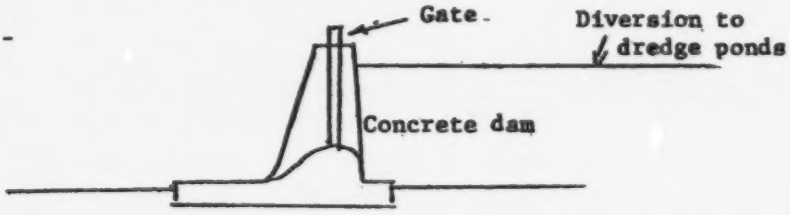
Pond - Dike Volumes. (Figures 16 & 17).

Pond No.	- Dike Type - (1) km	(2) km	(3) km	(4) km	Road km
1	4	1	1	--	--
2	2	1	1	1	2.0
3	1	--	1	½	1.0
4	1	--	½	1	Use plant road
5	2	--	--	2	1.0
6	2	½	--	1	--
7	2	--	1	3	2.0
8	2	½	--	3	1.0
9	1	--	1	1	--
Control dam	--	--	½	½	1.0
10	2	--	2	2	2.0
Control dam	2	1	--	--	0.2
Totals	21	4	8	15	10.2
Volume/km	5,000	20,000	60,000	13,000	
Total Volume/m^3	105,000	80,000	480,000	1,950,000	

Note: Topography in deep dike areas is critical.

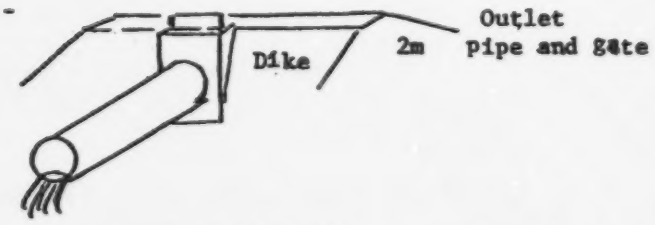
Dike Cost = $5/m^3$ x 2,615,000 m^3 = $13,000,000.
Roads = 10.2 km @ $25,000/km = $255,000.

Dams -



2 dams @ $100,000 = $200,000

Outlets -



10 outlets @ $10,000 = $100,000.

Total - Dikes, Roads, Dams & Outlets = $13,555,000.

Floating Wide-track Backhoes
for Dike Building

Aerial view of ditching through Louisiana marshland

Figure 16.

Excavators outfitted to exert only .098 kilograms/ sq. centimeter enabling them to virtually "walk on water"

Figure 17.

Omissions from Cost

1) Interest on funds -

These interest rates are so variable that the validity of peat dredging estimates are destroyed and interest needs to be introduced at the time a project feasibility study is made. Moreover, the greater part of interest presently represents inflation, therefore the value of the project equipment and property should increase accordingly, as well as would the dollar value of the product. Also, interest needs to be assessed as to source of funds. A peat development would undoubtedly receive development assistance, having as sources -

private capital
government grants
government subsidies
government assistance and services

2) Royalty -

These are unknown and could vary from no cost, on Crown land, to substantial cost, on private land.

3) Insurance - A small cost.

4) Obsolescence and depletion -

Depreciation is not as important to assess as is obsolescence. With a new industry, rapid new development of equipment could outmode dredging equipment. Depletion allowances are as yet not defined for peat mining.

5) Duties and federal sales tax -

A peat development, with research attributes, might well be tax and duty free.

6) Surge capacity -

No provision is made for surge capacity to cover the three-month annual shut-down period. Depending on process, it is visualized that there should be a surge pond built to contain pumped slurry peat, which would be recoverable by pumping or other means from the pond to the plant or, alternatively, by dry storage.

As the type of process plant is not known, but since, in any form of process plant, short-term surge capacity of three days would be necessary, the costs of same are as follows:

A surge pond for 3 days', short term, dredge production, to be built into the hillside, with an enclosing dike wall to contain the peat slurry; the whole to be surfaced with plastic or asphalt and the slurry recovery to be by pumping or other means suitable to the process plant in use.

3 days dredging capacity = 170,000 m^3 of slurry

Dike wall -

15 m height, 200 m long, 50 m wide

Dike volume -

35,000 m^3 @ \$7/m^3 = \$245,000

Tarring face -

300 m x 25 m = 7,500 m^2 @ \$2/m^2 = 15,000

Poly lining -

200 m x 70 m = 14,000 m^2 @ \$3/m^2 say,= 40,000

Pipes and pumps - = 300,000

\$600,000

10 years surge pond life = \$ 60,000 per year
Plus operating cost = 180,000 " "

\$240,000 per year

1.5 x 10^6 m^3 dry peat/year - \$0.16 per dry tonne of peat.

7) Process plant -

No plant charges are included for -

- process
- heat and pressure treatment to dewater
- dewatering mechanically
- treatment of plant water to be recirculated back to the dredge pond.

8) Plant moves -

No allowance is made for process plant moves to remain central to dredging. Such moves would be balanced against the cost of pipeline and power to pump greater distances. If the process plant were a simple dewatering plant, moves might be of low cost, however, if the process were a complicated one, longer piping distances might be advisable.

9) Pre-project engineering studies, surveys, bog sampling, testing and design.

Dikes Diversion Roads (see pages 31 and 32).

	Life (years)	Capital	Yearly
Dikes	10	$13,000,000	--
Roads	10	255,000	--
Dams	10	200,000	--
Outlets	10	100,000	--
		$13,555,000	$1,355,000

Costs - Recapitulation

Capital	$ 7,010,000	$ 462,000
Operating	1,367,000	2,701,000
Dikes diversion roads	13,555,000	1,355,000
Total	$21,932,000	$4,518,000

Tonnes (dry peat) per year - 1.5×10^6

Cost per tonne = $3.01

Summary

Costs Omitted -	Life (years)	Capital	Cost per tonne
Surge capacity	10	$ 600,000	$0.16
Interest for the first year $21,900,000 @ 15%, reducing yearly with depreciation - average $1,650,000			1.10
Royalty @ 20¢/tonne			0.20
Insurance			0.01
Taxes			--
Project initial engineering	10	600,000	0.04
		$1,200,000	$1.51

Cost of capital, dredge operation, dikes, diversion and roads		$3.01
Omissions from costs		1.51
Total Cost per tonne of dry peat delivered as a 7% - 8% slurry	=	$4.52

This unit price equates to a European fuel peat of 50% moisture at a per tonne cost of $2.26.

2. HUDSON BAY LOWLANDS PEAT DEPOSIT

There are tremendously large areas of deep peat in the Hudson Bay lowlands, south of the permafrost. Studies in the Onakawana area indicate peat depths exceeding five meters and railroad access is close by. (Figures 18 to 22 incl.).

This peat deposit is substantially deeper than the two other examples used and the extent of it is such that any number of dredging units could be used. Peat sampling has not been done and the topographical information is even less than for the western Ontario deposit.

The dredge ponds are visualized to accommodate a 24-inch dredge and its floating pipeline, a floating surge tank and a floating methanol process plant. The operation would be carried out during the eight warmer months of the year.

The worked-out peat lands could be used for the planting and harvesting of forest.

Other design considerations are as follows:

i) Life - 20 years, for one or more dredges.

ii) Topography - A gradual fall to the northeast of 12 meters in 20 kilometers.

iii) Yearly area required for harvest - 300 hectares.

iv) Average peat thickness - 5.3 m, of which 5.0 m is to be dredged.

v) Water supply - To be diverted from the adjoining river.

vi) Process plant - receives its peat slurry directly from the dredge. The methanol product is pipelined from the plant.

vii) The dredge - is a 24-inch cutter-suction dredge, pumping through a 24-inch floating pipeline of 0.5 to 4.0 kilometers in length.

viii) Production season - is 8 months per year, operating 24 hours per day, of which the dredge pumps slurry 19½ hours per day, using a 65% efficiency pump.

ix) Surge tank and methanol process plant - floats in the dredge pond.

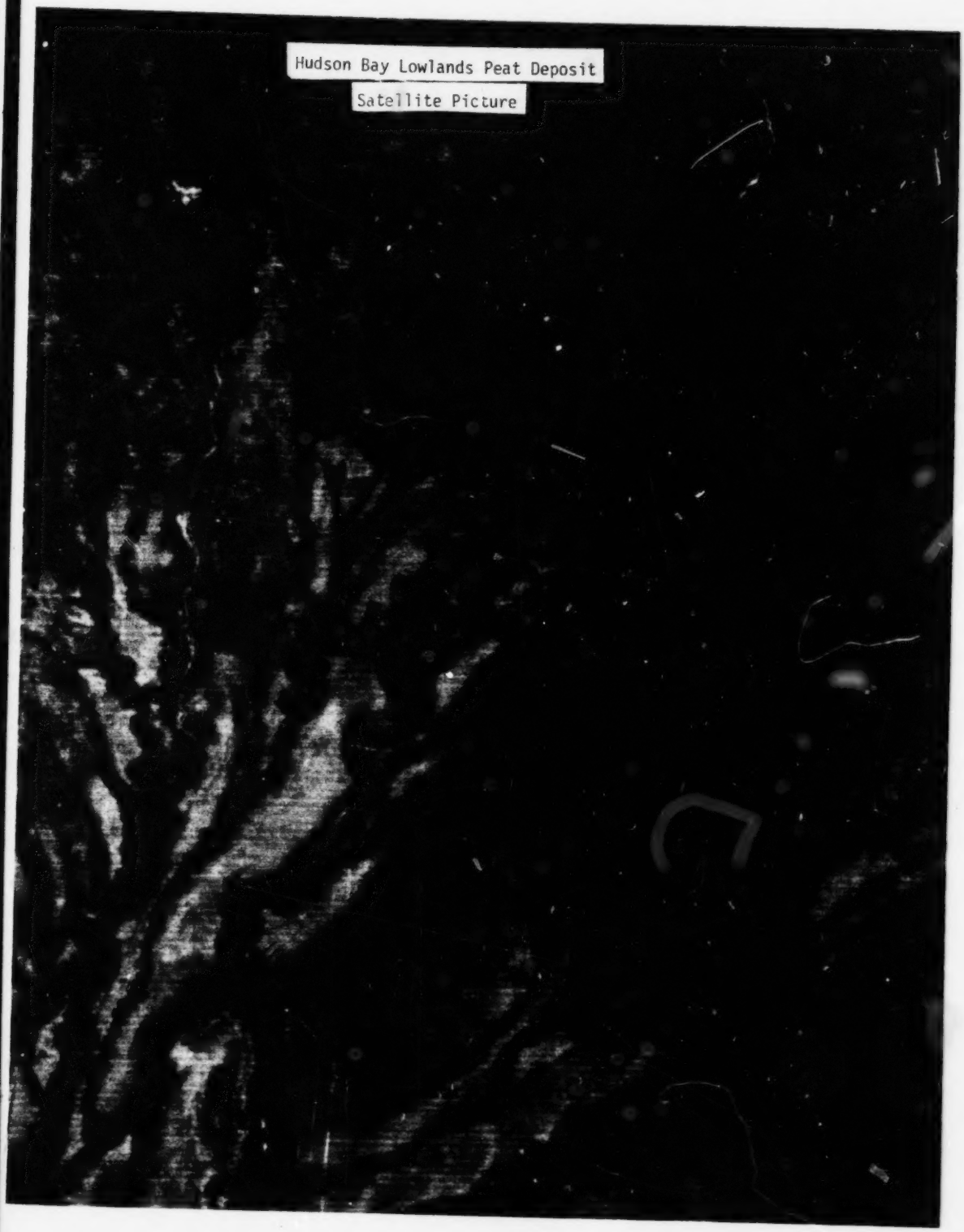


Figure 18

Hudson Bay Lowlands Peat Deposit

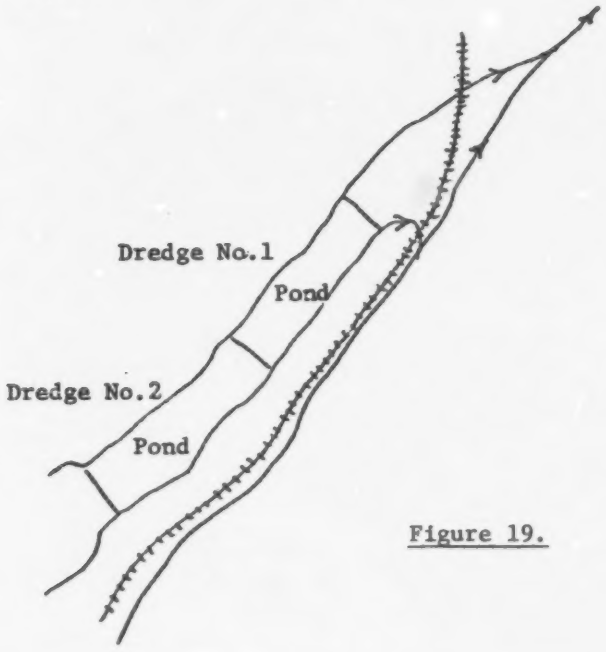


Figure 19.

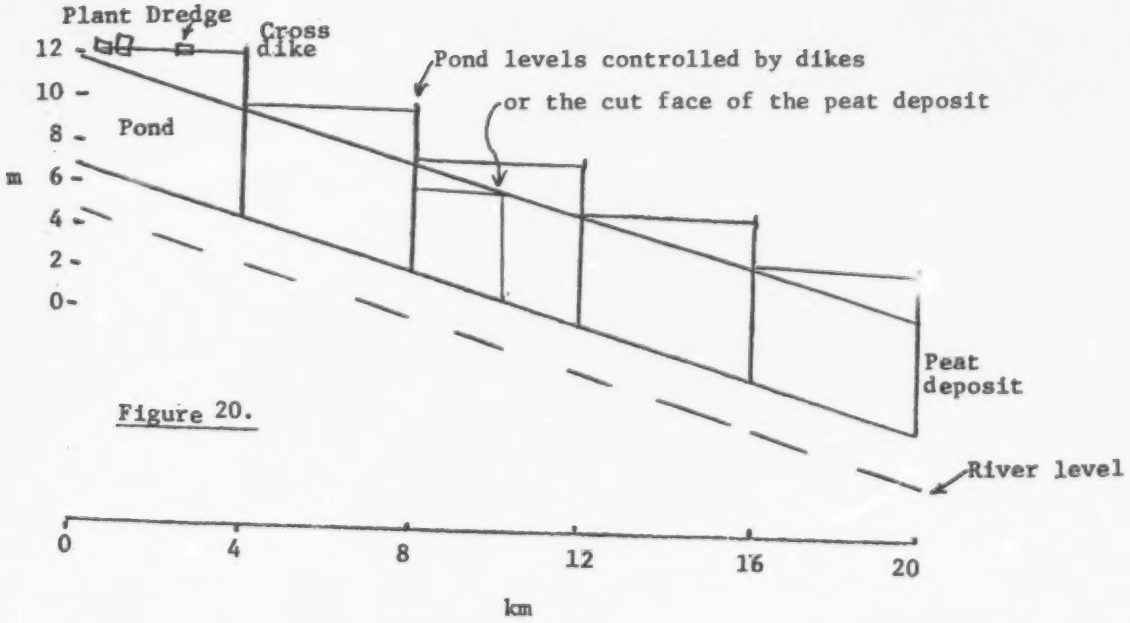


Figure 20.

Hudson Bay Lowlands Peat Deposit

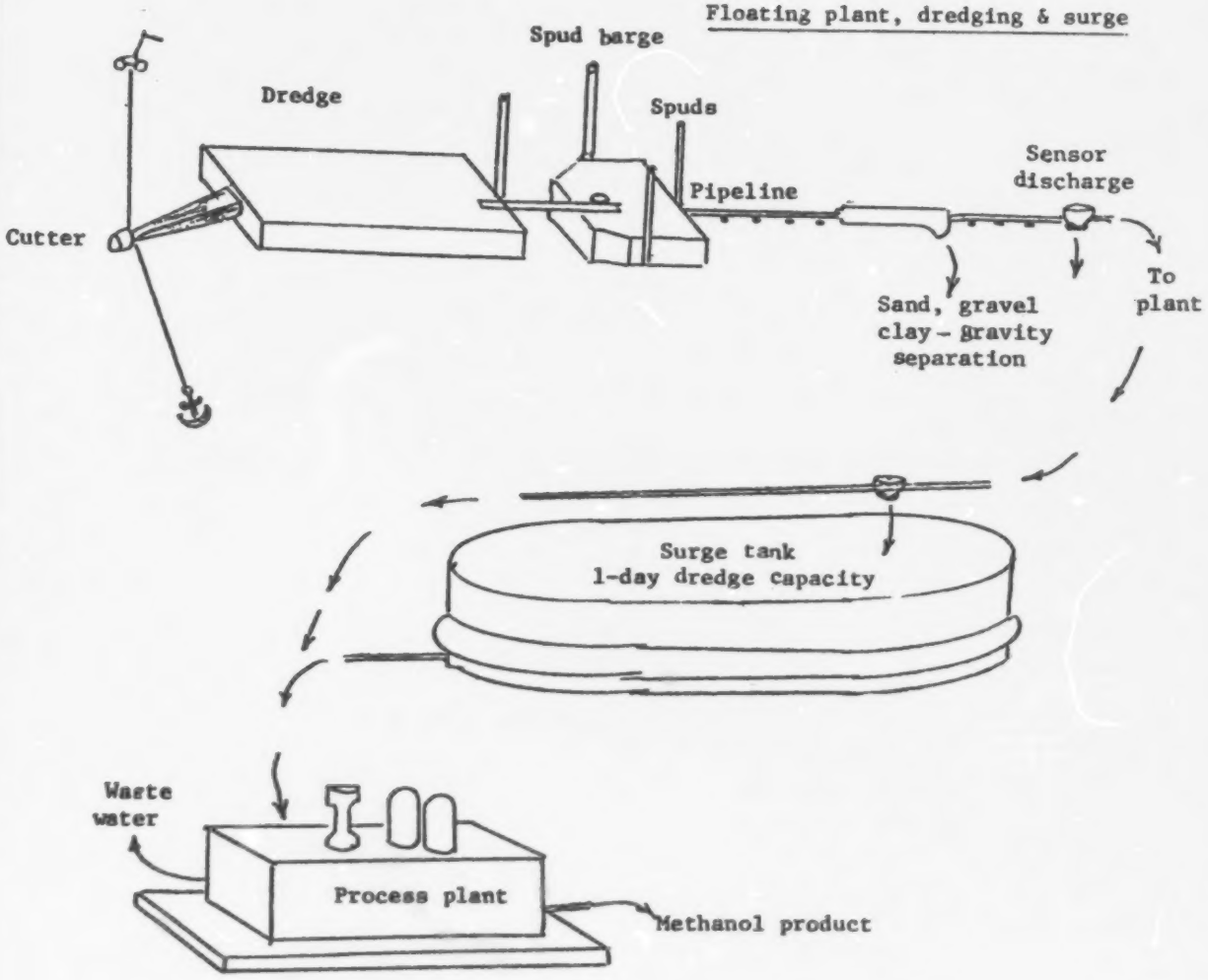


Figure 21.

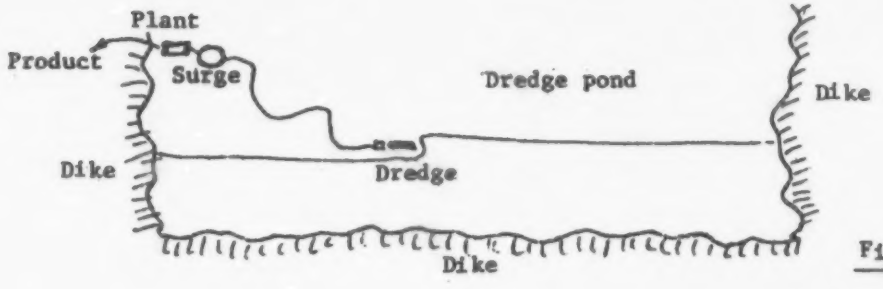
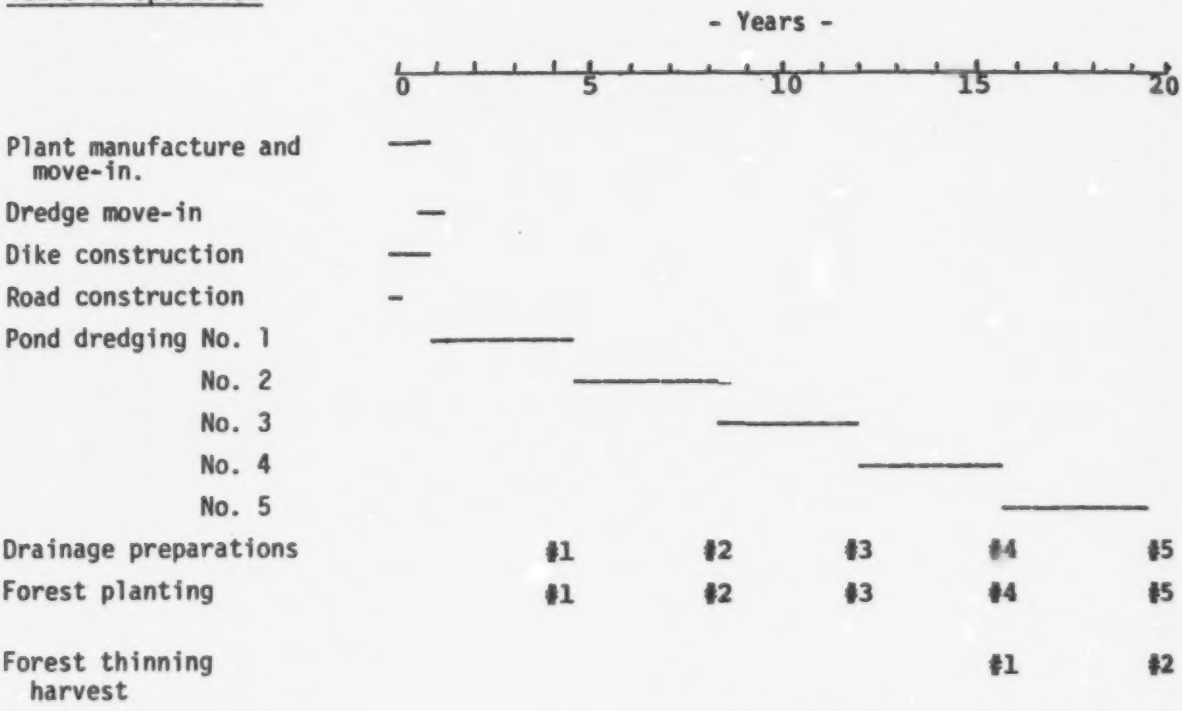


Figure 22.

Hudson Bay Lowlands Peat Deposit

Years of Operation



24-inch Dredge - 24-inch Pipeline

In situ peat - 90% water by weight
- Specific gravity 1.0
- Diluted at the cutter-head by an added 25% water.
- Lost time in a 24-hour dredging day is 4.5 hours.

The 24-inch dredge pumps at 12 feet per second velocity in the dredge pipe.

= 3,839 m^3 per hour
Representing 3,071 m^3 per hour of in situ peat
or 307 tonnes (dry) peat per hour.

In 8 months (30 days/month, 19½ hours cutting per day),

the dredge cuts 1.4×10^7 m^3 in situ peat
to produce 1.4×10^6 tonnes (dry) peat
requiring 280 hectares
say, 300 hectares per year of 5 m deep peat.

Dredge and Pipeline Head Losses

	Pipe length 3 km (feet)	Pipe length 4 km (feet)
Dredge suction loss	20	20
Dike rise	--	--
Plant and surge pond rise	40	40
Pipe friction	33	270
	93 ft.	330 ft.
or,	28.4 m	100.7 m

Horsepower Required

On board dredge.

Dredge pump 65% efficient	216 HP	1764 HP
Cutter	500	500
Winches	200	200
Welders, lights, heat	100	100
Spud barge	200	200
	1216	2764

average, say - 2,000 HP
or - 1,492 kW

(No booster pumps are required.)

Capital Costs

	Life (years)	Capital	Yearly
Dredge move-in	20	$ 500,000	$ 25,000
Dredge	20	3,100,000	155,000
Spud barge	20	400,000	20,000
Booster pump	--	--	--
Powerlines, cable & barge	20	260,000	13,000
Auxiliary equipment:			
Tugs	20	400,000	20,000
Floating backhoe	20	260,000	13,000
D-6 bulldozer sideboom	5	120,000	24,000
Crew boats	20	60,000	3,000
Work barges	20	320,000	16,000
Service trucks	6	70,000	12,000
Pickups	3	60,000	20,000
Swamp buggies	5	200,000	40,000
Welders, small tools	10	60,000	6,000
Buildings - mechanical, office, dry, warehouse	20	500,000	25,000
houses	20	150,000	7,000
Total		$6,460,000	$399,000

Operating Costs

Pipe - 4 km floating @ $60/ft.	4	$ 790,000	$ 200,000
Horsepower- 2000 @ $90/HP year		--	180,000
Crew:			
3 shifts 5 men = 15 1 shift 10 men = 10 25 men			
8 hours per shift, 30 days/month, 9 months/year			
2160 hours x 25 men @ $28/hour (including overtime and social legislation) Maintenance labour included.		--	1,500,000
Travel		--	25,000
Camp: @ $30/man-day		--	225,000
Maintenance materials		--	300,000
Clearing - 300 hectares @ $100/ha		--	30,000
Pond water recirculation		--	--
Total		$ 790,000	$2,460,000

Dikes and River Diversion

The peat deposit to be dredged lies between two rivers that, in flooding, have built up natural levees along their banks. To contain dredge pond waters, these levees would have to be built up, or trimmed in places, and could serve as roads. (Figures 23, 24 & 25).

The depth of the peat deposit, at over 5 meters, is adequate to contain the pond waters as the dredge cuts in a downstream direction. However, some provision for cross-diking has been provided, should such be advisable in certain places.

A diversion dam would be built at the upstream end of one of the rivers to supply make-up water for the dredge ponds.

Cost:	Life (years)	Capital	Yearly
Diversion dam	20	$2,500,000	$125,000
River levee heightening 105,000 m^3 @ $4/$m^3$	4	420,000	105,000
Cross dikes 260,000 m^3 @ $4/$m^3$	4	1,040,000	260,000
Total		$3,960,000	$490,000

Surge Tank

1 day's dredge production capacity - 80,000 m^3

Tank dimension - 36 m radius
20 m height
reinforced base

Tank designed to float empty at 0.5 m draft; to sit on the bottom fully loaded.

Value -

Covered tank (steel)	$2,800,000			
Open tank	$1,900,000			
Plastic-roofed tank	-	20	$2,000,000	$100,000

Methanol Process Plant - 1500 tons.

Barge-mounted
Dimension - 40 x 50 x 3 m
Draft - 1.1 m

Hudson Bay Lowlands Peat Deposit

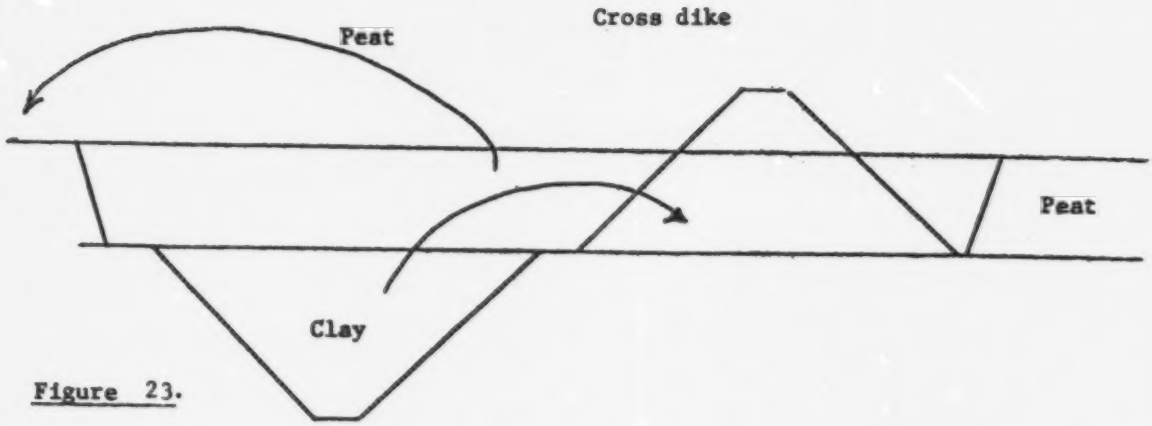


Figure 23.

Lateral levee improvement

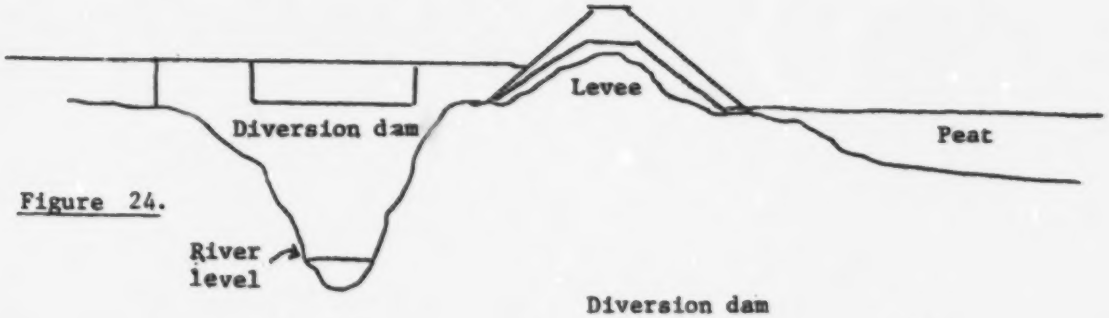


Figure 24.

Diversion dam

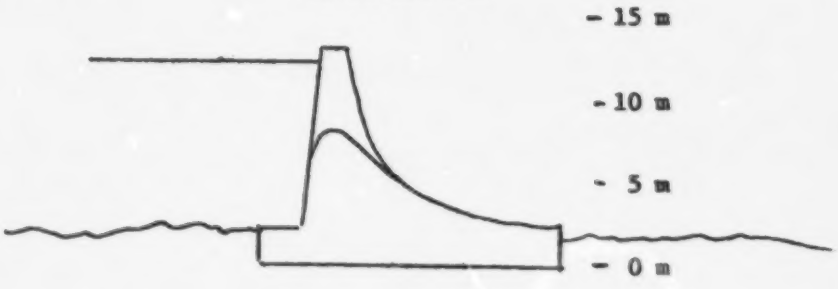


Figure 25.

Cost Recapitulation

	Capital	Yearly
Capital	$ 6,460,000	$ 399,000
Operating	790,000	2,460,000
Dikes & diversion	3,960,000	490,000
	$11,210,000	$3,349,000

Tonnes (dry peat) per year 1.4×10^6 = $2.39 Cost per tonne.

The principal reason that unit cost for the Hudson Bay lowland is less than for the western Ontario deposit is that diking requirements are less costly and the dam or dams are usable for 20 years instead of 10. The greater depth of peat and extent of the deposit reduces costs substantially.

Omissions from Cost

	Life (years)	Capital	Yearly	Cost per tonne
Surge capacity	20	$2,000,000	$100,000	$0.07
Interest - First year $11,210,000 @ 15% = $1,680,000, reducing yearly with depreciation - average = $840,000				0.60
Royalty				0.20
Insurance				0.01
Taxes				--
Project initial engineering	20	800,000	40,000	0.03
				$0.91

Cost of capital, dredge operation, dikes, dams - $2.39

Omissions from cost - 0.91

Total Cost per tonne of dry peat, delivered as a 7% to 8% slurry - $3.30

3. SOUTHERN ONTARIO PEAT DEPOSIT

This deposit of over 4,000 hectares lies in a flat river valley, which slopes very gently towards a lake. A 16-inch dredge is employed for 20 years to pump to a centrally-located shore surge pond and process plant, to produce fuel peat. The maximum dredge pumping distance is 15 kilometers. (Figures 26 & 27)

The subsequent land use would be to provide very valuable market garden land. The dredging itself requires little dredge pond control or diking, as the valley is enclosed by hills, but as it is desired that market garden lands be produced, a canal is designed to divert the river, and dikes are built across the valley so that, when a pond area has had the peat removed and the dredge moves on to a succeeding downstream pond, the dredged out area may be pumped dry, levelled, ditched and prepared for market garden planting the following year.

Other design considerations are as follows:

i) Life - 20 years.

ii) Topography - a 3 m fall down river, in 24 km.

iii) Yearly area required for dredging - 370 hectares.

iv) Average peat thickness to dredge - 2.0 meters.

v) Water supply - from river diverted by canals.

vi) Process plant and wet surge storage - are centrally-located on the north side of the peat deposit.

vii) The dredge - is a 16-inch cutter-suction dredge, pumping through a 16-inch pipeline 3 km to 16 km in length.

viii) Production season - 9 months per year, operating 24 hours per day, of which the dredge pumps slurry 18½ hours, with a 65% efficiency pump.

ix) Cross dikes - for the purpose of separating previously dredged areas for dewatering, levelling and preparing for market gardening.

Southern Ontario Peat Deposit

Ponding and river diversion by canals.

Were peat dredging the only consideration, dredge ponding would be of little cost. The use to which the land will be put after the peat has been removed is therefore made to bear these costs.

Figure 26.

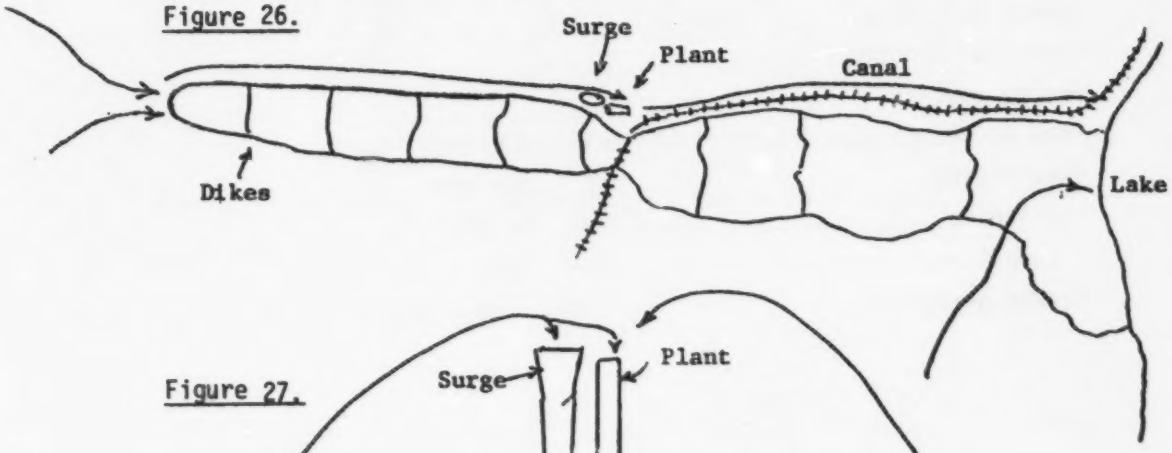
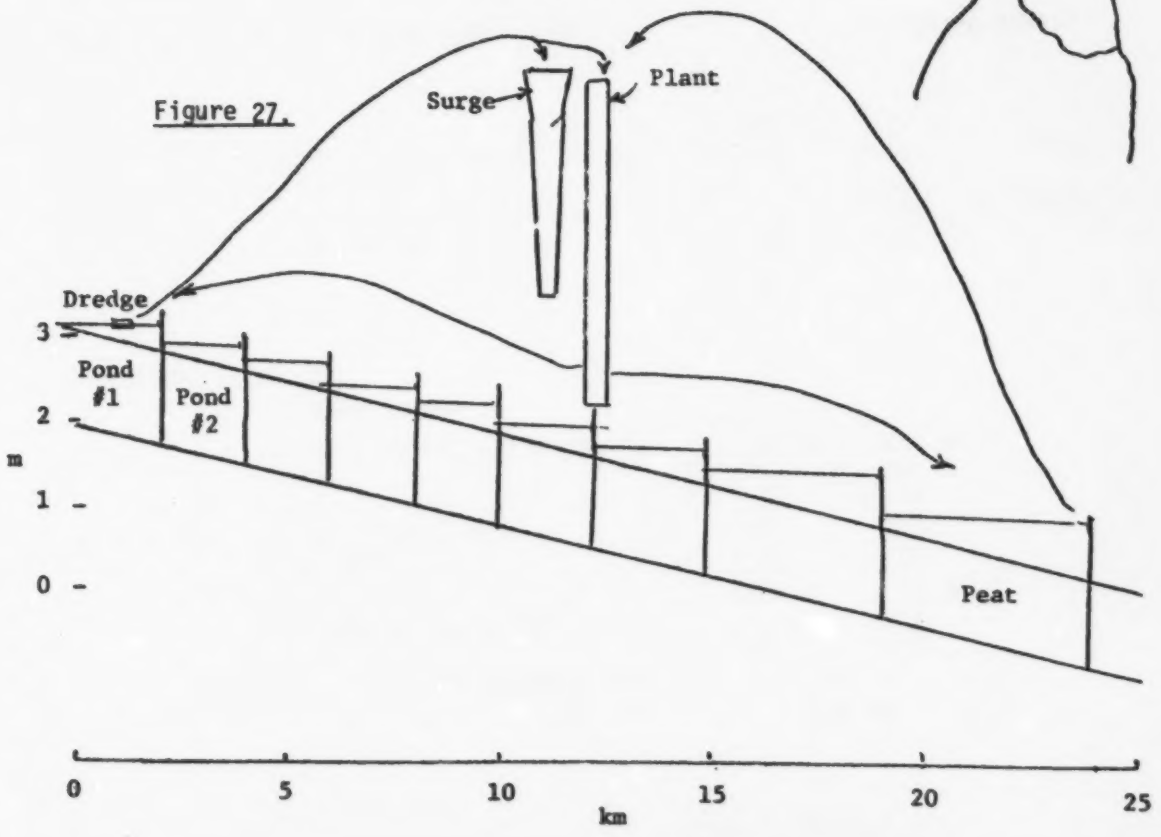
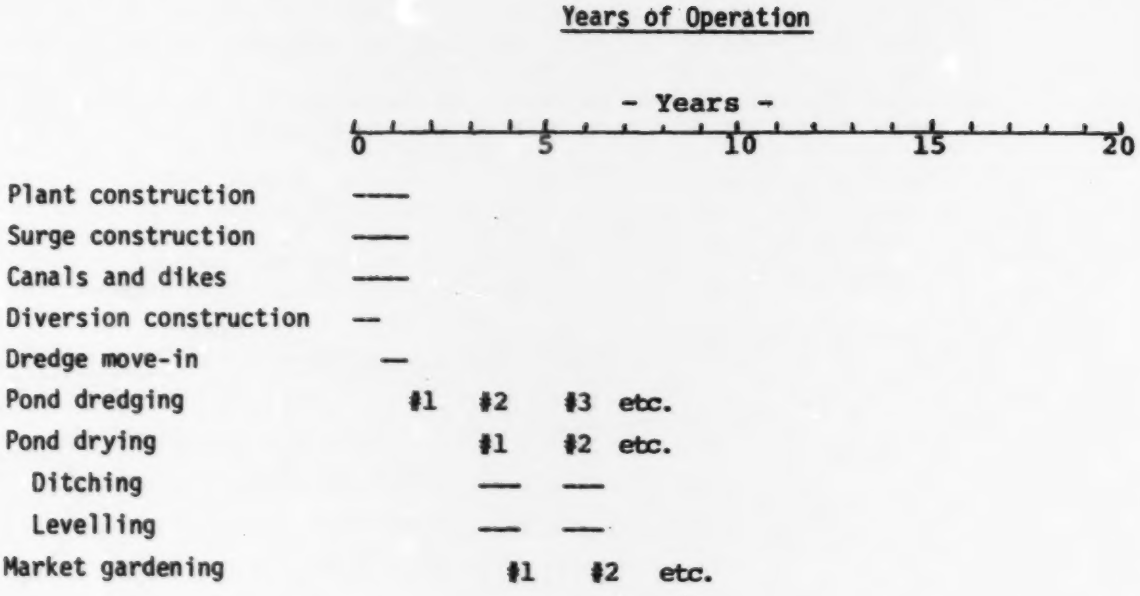


Figure 27.



Southern Ontario Peat Deposit



16-inch Dredge - 16-inch Pipeline

- Pumping at 12 feet per second velocity
- In situ peat 90% water by weight
- Specific gravity 1.0
- In situ peat diluted at the cutter-head by an added 25% water.
- Lost time in a 24-hour dredging day is 5.5 hours.
- The 16-inch dredge pumps 1,690 m^3 per hour

In 9 months, 30 days/month, 18½ hours/day,

dredge cuts - 6.75×10^6 m^3 of in situ peat

to produce - 6.7×10^5 tonnes of dry peat

requiring - 335 hectares

say, - 370 hectares per year of 2 m deep peat.

The peat deposit is 2500 m wide or more, requiring a yearly dredging advance downstream of 1.48 km and less, where the deposit widens.

Dredge and Pipeline Head Losses

	Pipe length 3 km (feet)	Pipe length 15 km (feet)
Dredge suction loss	20	20
Dike rise	--	--
Plant and surge pond rise	50	50
Pipe friction	289	1443
	359	1513

Horsepower Required

On board dredge.

Dredge pump 65% efficient	850 HP	850 HP
Cutter	250	250
Winches	75	75
Welder, light, heat	100	100
Spud barge	75	75
	1350 HP	1350 HP
Boosters on shore (4)	--	3300
	1350	4650

average, say, - 3,000 HP

or, - 2,238 kW

Capital Costs

	Life (years)	Capital	Yearly
Dredge move-in	20	$ 300,000	$ 15,000
Dredge	20	1,500,000	75,000
Spud barge	20	200,000	10,000
Booster pumps (4 @ $500,000 each)	20	2,000,000	100,000
Powerlines, cable & barge	20	300,000	15,000
Auxiliary equipment:			
Tugs	20	200,000	10,000
Floating backhoe	20	260,000	13,000
Bulldozer sideboom	5	120,000	24,000
Crew boat	20	60,000	3,000
Work barges	20	200,000	10,000
Service truck	6	30,000	5,000
Swamp buggy	5	100,000	20,000
Welder, small tools	10	60,000	6,000
Buildings - mechanical, office, dry, warehouse	20	400,000	20,000
Spare parts	10	100,000	10,000
Total		$5,830,000	$336,000

Operating Costs

	Life (years)	Capital	Yearly
Pipe -			
floating - 9500 feet @ $40/ft.	4	$ 380,000	$ 95,000
land - 38000 feet @ $20/ft.	6	760,000	127,000
Horsepower- 3000 @ $90/HP year		--	270,000
Crew - 3 shifts 4 men = 12 1 shift 8 men = 8 20 8 hours per shift, 30 days per month, 10 months per year 2400 hours x 20 men @ $20/hour (including overtime and social legislation) Maintenance labour included		--	960,000
Travel		--	25,000
Camp		--	--
Maintenance materials		--	200,000
Clearing - 370 hectares @ $100/ha		--	37,000
Pond water recirculation	10	400,000	40,000
power and labour			30,000
Total		$1,540,000	$1,784,000

Dikes and River Diversion

These costs would be undertaken only if the dredged land were to be put to use for market gardening. If that were not a consideration, the dredge ponding would be very inexpensive. Therefore dike and canal cost will not be included in the cost of dredging.

Cost Recapitulation

	Capital	Yearly
Capital	$5,830,000	$ 336,000
Operating	1,540,000	1,784,000
Dikes & Diversion	--	--
	$7,370,000	$2,120,000

Omissions from Cost

Surge capacity is provided to accommodate 3 days' dredge production. The surge pond would be built into a hill adjacent to the process plant.

	Life (years)	Capital	Yearly
3 days' dredge capacity - 93,000 m^3 slurry	20		
Dike - wall - 9 m height, 200 m long, 50 m wide clay volume - 100 m^2 x 250 m long = 25,000 m^3 @ $7/$m^3$		$ 175,000	
Tar face - 300 m^2 x 15 m = 4500 m^2 @ $2/$m^2$		9,000	
Poly lining - 250 m x 80 m = 20,000 m^2 @ $3/$m^2$		60,000	
Pipes, pumps		300,000	
Total		$544,000	$27,200

Cost per tonne (dry) peat = $0.04
Plus operating cost = 0.12
$0.16 per tonne (dry) peat.

Dikes and River Diversion

The following data is not included in the cost of dredging, but is shown to give some idea of what it might cost in addition to that of dredging of land development for market gardening, if this were to be considered. Such land is highly productive when farmed intensively providing as much as three crops per summer. It is said that 15 acres will support a farmer rather handsomely.

	Capital cost of land reclamation
Left bank -	
Canal length - 15 km	
Road & canal excavation - 24 m x 4 m x 15 km = 1,500,000 m^3 @ \$5/m^3	\$7,500,000
Gravel road surface - 0.3 m deep x 8 m x 15 km = 36,000 m^3 @ \$8/m^3	300,000
Diversion dam -	200,000
2 bridges -	60,000
Clearing - 30 m x 15 km = 45 hectares @ \$1000/ha	45,000
	\$8,105,000
Right bank - plus canal and road	4,000,000
	12,105,000
Cross dike (5) -	
2.5 km long (each)- 13 m^2 dike section = 5 x 2500 m x 13 m^2 = 160,000 m^3 @ \$5/m^3	800,000
	\$12,905,000

VII. CONCLUSIONS

1. Cutter suction dredging of peat is believed to be suitable for the mining of Ontario peat deposits. However, only larger deposits of suitable depth and quality could support a scale of operation that would be economically viable.

2. In choosing peat deposits for development, it would be preferable, at least initially, to select deposits close to existing road or rail access and power supply.

3. Canada has a plentiful supply of skilled people, familiar with dredging, who could undertake peat dredging with little added training required.

4. Dredging could be carried on 8 to 9 months yearly in Canada, depending on the local climate. Year-round dredging has been done in western Ontario, but whether the same can be done with peat dredging would require further site specific study to ascertain.

5. There are a number of restraints to dredging of peat that call for changes in standard dredge design, some of which have already been discussed in this text.

6. Only selected peat deposits are suitable to dredging, such as deposits where large quantities of water additional to that found in the bog would be available for ponding to float the dredge. Also environmental requirements in that respect would have to be satisfied.

7. Economic assessment of dredging in southern Ontario should take into account the added value of land improved by dredging. The long term socio-economic advantage could be very high, expecially in the case of market garden peat lands.

8. The Hudson Bay lowlands that lie to the south of the southern limit of permafrost present large-scale long term dredging and processing opportunities which can be carried out at very low dredging costs.

9. Cost Sensitivity in Peat Dredging.

   a) Peat slurry percentages pumpable -

      Both Fisons-Western Peat Corporation and Dravo Corporation consider that peat slurries exceeding 3% peat by weight are unpumpable. However it must be remembered that the former is dealing with peat moss, which differs markedly from the fuel peat considered in this study. In addition, they wash much of the fines away before pumping.

The various operators who use cutter-suction dredges are of quite another opinion and generally believe that in situ peat of 10% solids can be pumped, after maceration with a bladed cutter-head. For the purposes of this study, it is considered that the dredge cutter suction action cannot be constantly maintained at the peat face and this will cause 25% water to be added, to produce a slurry of 7% to 8% by weight.

There is a further caution for those selecting peat deposits to be dredged. A 95% water in situ peat (by weight) has double the water content of a 90% deposit. Thus the dredge, in pumping equal volumes, would move only half as much peat at 95% and costs would approximately double per unit of peat.

Dredge operators have no actual proof of their assertions on pumpable slurries, as peat is usually excavated in association with other mineral soils. Were a field experiment to be carried out to prove this matter, it is believed that it could only be performed at full-scale, in the field. A dredge to be so employed would require substantial alteration to perform in peat. Such a test would require considerable pre-planning and should address all aspects of peat dredging that might be in question for a specific site.

b) Dike design and construction for peat deposits presently lack basic information on topography, both surface and subsoil, peat quality and quantity definition, water supplies available and moreover, environmental requirements for Ontario peat deposits suitable to dredging is lacking. Thus, dike quantities calculated in this study could easily vary upward or downward, if more accurate topography and drill data were available..

c) The larger the dredge that can be efficiently operated in a peat deposit, the cheaper the unit cost should be. For example, labour crews do not vary appreciably with the size of the dredge. On the other hand, friction in the dredge pipeline varies directly as the square of the pipe radius, and horsepower varies as the cube of the pipe radius.

d) Until the dredger knows to what process plant he is to deliver the peat, he cannot assess special dredging provisions to be made, nor can he decide the volume or condition of the water to be returned to the dredge pond by the plant.

e) Peat deposits contain methane gas up to 10% by volume, which must be removed from the dredge pump intake, lest it break the pump vacuum. This gas could provide substantial benefits for heating parts of the project. (See "Muskeg Engineering Handbook".)

10. Comparison of Costs of the Three Ontario Peat Deposits Covered

	Western	Hudson Bay Lowlands (A floating plant)	Southern
Dredge size	24 inch	24 inch	16 inch
Dredging season	9 months	8 months	9 months
Peat depth dredged	2 meters	5 meters	2 meters
Annual production dry peat (tonnes)	1.5×10^6	1.4×10^6	0.67×10^6
Horsepower -			
Dredge on board	2,300	2,800	1,350
Booster pump	1,300	--	3,300
Pipeline max. length	7 km	4 km	15 km
Capital Cost -			
Dredge	$4,160,000	$4,260,000	$2,300,000
Booster pump	$600,000	--	$2,000,000
Auxiliary equipment	$2,250,000	$2,200,000	$1,530,000
Annual crew cost	$1,725,000	$1,750,000	$985,000
Dikes, diversions, dams, roads (over 20 years)	$27,000,000	$6,410,000	(chargeable to land development)
Dredge - Capital & Operating Cost (including dikes) per dry tonne peat)	$3.01	$2.39	$3.16
Omitted Cost - per dry tonne	$1.51	$0.91	$1.23
Total Cost - per dry tonne of peat	$4.52	$3.30	$4.39
Subsequent land use	Biomass	Forestry	Market gardening

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